CLINICAL AND ELECTROPHYSIOLOGICAL EVALUATION OF PATIENTS WITH DIABETIC NEUROPATHY

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CERTIFICATE

This is to certify that this dissertation entitled **"CLINICAL AND ELECTROPHYSIOLOGICAL EVALUATION OF PATIENTS WITH DIABETIC NEUROPATHY"** submitted by **Dr. V.Kannan** appearing for **D.M.,** Degree examination in **August 2009** is a bonafide record of work done by her under my direct guidance and supervision in partial fulfillment of regulations of the Tamil Nadu Dr. M.G.R. Medical University, Chennai. I forward this to the Tamil Nadu Dr.M.G.R. Medical University, Chennai, Tamil Nadu, India.

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The dissertation is submitted to The Tamilnadu Dr. M.G.R. Medical University towards the partial fulfillment of requirements for the award of **D.M., Degree in Neurology.**

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CONTENTS

INTRODUCTION

Peripheral neuropathy caused by Diabetes (DM) was recognised only in 1864 by Marchel de Calvi.(1) Till then it was assumed that diabetes was caused by disease of the nervous system. However, once the relationship was rightly recognized, much documentary evidence soon emerged regarding the various clinical manifestations occurring in diabetic peripheral neuropathy. Thus, the loss of tendon reflexes in the legs was described by Bouchard (1887),(2) similarities to tabes stressed by Althaus (1885)(3), spontaneous pain and hyperesthesia by Pavy (1885)(1904)(6) and motor manifestations by Bruns (1890)(6) and Charcot (1890) and cranial nerve involvement by Ogle (1896).(8) While Leyden (1893)(9) and Pryce (1893)(10) set out a classification of the different manifestations of the disease, is was Rundles11 who in 1945 first drew attention to the autonomic nerve involvement in diabetes. Later, scientists turned their interest to the etiopathogenetic mechanisms resulting in peripheral neuropathy. This in turn gave impetus to the experimental production of diabetic neuropathy (DN) in order to understand the evolution of the disease. Though a large volume of work has been carried out in this regard and many problems solved, many questions still remain unanswered. There is a need, therefore, for more comprehensive studies of the prevalence, severity, natural history, and cause of specific types of diabetic neuropathy.

AIMS AND OBJECTIVES

1. To assess the incidence of various types of Diabetic Neuropathies
2. To examine the Clinical Profile of each type of Diabetic Neuropathy
3. To study the Neurophysiologic patterns in each type of Diabetic Neuropathy and the extent of their clinical correlation.

REVIEW OF LITERATURE

Diabetes mellitus imposes substantial burdens on the nervous system and is the most common cause of neuropathy or peripheral nerve damage. Moreover, diabetic neuropathies are rising in prevalence with the growing global burden of type II diabetes mellitus. Although this review emphasizes peripheral nerve disorders, there is now recognition that diabetes also targets the central nervous system, especially white matter (diabetic leukoencephalopathy). (24,25) Within the peripheral nervous system alone, however, diabetes renders several types of nerve damage, including diffuse damage (polyneuropathy) and focal damage (mononeuropathy). Both contribute to sensory and motor deficits and both are associated with significant disability in patients. In polyneuropathy it is now recognized that impaired glucose tolerance, even without overt diabetes mellitus, may be a risk factor.

The San Antonio Consensus criteria are commonly used to define diabetic neuropathy for research purposes.(26) For clinical neuropathy, the guidelines require symptoms and signs, or one of these with abnormal testing (nerve conduction, quantitative sensory testing, or autonomic testing). Subclinical neuropathy is identified by abnormal testing only. More specific staging of diabetic polyneuropathy (DPN) has also been described by Dyck and Dyck**(27)**: NO, no neuropathy; N1, asymptomatic neuropathy without (N1a) or with (N1b) findings on neurological examination; N2, symptomatic; N3, disabling. Both pathophysiology and therapy for diabetic neuropathies remain challenging. There has been a long history of failed clinical trials for polyneuropathy, in part related to issues of what was targeted, what was being measured, and how well the trial was designed. Despite these problems, there are new and exciting thoughts about how these disorders develop and what avenues may offer

significant hope. Because of the size of the topic, a number of aspects are only covered briefly in this review and the bias is toward emphasizing aspects of its neurobiology. Three excellent and comprehensive texts addressing diabetic neuropathy have been published (28,29,30) in addition to recent reviews addressing slightly different points of view, and diagnostic criteria have recently been published by the American Diabetes Association.(31)

CLASSIFICATION AND PREVALENCE

Diabetic neuropathies comprise diabetic polyneuropathy (DPN), a symmetric diffuse disorder that particularly targets sensory neurons with long axons, and focal neuropathies or mononeuropathies. The latter include classic entrapment neuropathies that are more common in diabetes such as carpal tunnel syndrome (CTS), ulnar neuropathy at the elbow (UNE), meralgia paraesthetica (entrapment of the lateral femoral cutaneous nerve of the thigh) at the inguinal ligament, or peroneal neuropathy at the fibular head. Other mononeuropathies much more specifically identified in diabetic patients include intercostal and abdominal segmental radiculopathies, oculomotor palsies, and lumbosacral radiculoplexus neuropathies.

Brown and Asbury (32) subdivided DPN clinically into subtypes, with the group of mixed motor, sensory, and autonomic neuropathy representing 70% of patients. A predominantly sensory phenotype was found in 39% that was yet further divided into large-fiber, small-fiber, or mixed neuropathies. Pure motor DPN or autonomic DPN were uncommon (_1% each). In the author's experience, pure sensory DPN on the basis of clinical evaluation alone (some have subclinical electrophysiological motor involvement) represents the large majority of patients, particularly early in their course. Some have added a category of an acute sensory DPN with rapid onset (likely overlapping with a condition known as "insulin neuritis"

or neuropathy after the onset of insulin use), an association with acute hyperglycemia, the presence of prominent pain, and a shorter overall duration related to control of hyperglycemia.

The reported prevalence of DPN varies with the type and the intensity with which it is sought. In the classic Diabetes Control & Complications Trial (DCCT) of diabetic complications in intensively rather than conventionally treated patients with type I diabetes mellitus,46 clinical neuropathy was defined as an abnormal clinical neurological examination plus either abnormal nerve conduction in at least two peripheral nerves or unequivocally abnormal autonomic-nerve testing. In patients without neuropathy at baseline, 9.8% of conventional and 3.1% of intensively treatment patients had developed it by 5 years. For patients in the secondary intervention cohort with retinopathy at baseline but not neuropathy, the rates were 16.1% for conventional and 7.0% for intensive treatment. Overall, when looking at a variety of studies (summarized by Shaw et al).(33), type I diabetic prevalence figures vary from 13%–17% in hospitalized patients based on symptoms and signs, and 8%–54% with more comprehensive batteries in primary care or population-based screening. For type II diabetic patients, similar figures run from 19%–58% in hospital-based studies with some ancillary testing and 13%–46% in primary care or population-based screening more heavily weighted toward testing.

There are likely significant flaws, however, from relying on hospital-selected data. With very comprehensive and extensive batteries of evaluation, such as that applied to the Rochester Diabetic Cohort (*n* _ 380), evidence of DPN was identified in 54% of type I diabetics and 45% of type II diabetics. Using the strict criteria of an abnormal neuropathy impairment scale (NIS) and seven abnormal laboratory studies, 21% of the Rochester diabetic cohort had DPN. Symptomatic DPN was identified in a smaller proportion, 13%–15%. In other cohorts, such as

the Pittsburgh epidemiology of diabetes complications (*n* _ 400), DPN was identified in 34% of type I diabetics, whereas in the San Luis Diabetes Study DPN was present in 26% of type II diabetics (*n* _ 279). In patients with impaired glucose tolerance only, as a precursor of type II diabetes, the prevalence figures have been more controversial. The prevalence of cardiovascular autonomic neuropathy detected by heart-rate interval studies (including the response to Valsalva's maneuver, or deep breathing) has ranged from _16%–25% in type I and II diabetic patients, with a smaller proportion having symptoms.

Several studies have suggested that cardiovascular autonomic neuropathy is a risk factor for increased mortality. For gastrointestinal symptoms, prevalence figures are also variable, with numbers for constipation or diarrhea ranging between 3% and 35%. Impotence has been identified in 23%–57% of type I and II diabetic men, with higher rates with increasing age.(33) Overall, a population-based study from the Rochester diabetic cohort (*n* _ 231 diabetics) identified a prevalence of autonomic dysfunction (using a composite scale of laboratory-based autonomic tests known as CASS) of 54% in type I diabetics and 73% in type II diabetics, with postural hypotension in 8.4% and 7.4%, respectively.

INDIAN SCENARIO

There is a higher prevalence of DM in India (4.3%)(34) compared with the West (1%–2%).(35) Probably Asian Indians are more prone for insulin resistance and cardiovascular mortality.(37) The incidence of DN in India is not well known but in a study from South India 19.1% type II diabetic patients had peripheral neuropathy.(38) DN is one of the commonest causes of peripheral neuropathy. It accounts for hospitalisation more frequently than other complications of diabetes and also is the most frequent cause of non-traumatic amputation.

Diabetic autonomic neuropathy accounts for silent myocardial infarction and shortens the lifespan resulting in death in 25%– 50% patients within 5–10 years of autonomic diabetic neuropathy.(39,40) According to an estimate, two thirds of diabetic patients have clinical or subclinical neuropathy.

The diagnosis of subclinical DN requires electrodiagnostic testing and quantitative sensory and autonomic testing. All types of diabetic patients—insulin dependent diabetes mellitus (IDDM), non-insulin dependent diabetes mellitus (NIDDM), and secondary diabetic patients—can develop neuropathy. The prevalence of neuropathy increases with the duration of diabetes mellitus. In a study, the incidence of neuropathy increased from 7.5% on admission to 50% at 25 years follow up.(41) This box gives the classification of DN(42).

CLINICAL CLASSIFICATIONS OF DIABETIC NEUROPATHIES

Symmetric

- Diabetic polyneuropathy
- Painful autonomic neuropathy
- Painful distal neuropathy with weight loss “diabetic Cochexia”
- Insulin neuritis
- Polyneuropathy after ketoacidosis
- Polyneuropathy with glucose impairment
- Chronic inflammatory demyelinating polyneuropathy with diabetes mellitus

Asymmetric

- Radiculoplexoneuropathies
    - Lumbosacral

- Thoracic
- Cervical

- Monoeuropathies
- Median neuropathy at wrist
- Ulnar neuropathy at the elbow
- Peroneal neuropathy at the fibular head
- Cranial neuropathy

DISTAL SYMMETRICAL POLYNEUROPATHY (DSPN)

DSPN is the commonest type of DN and probably accounts for 75% of DNs. Many physicians incorrectly presume that DSPN is synonymous with DN. It may be sensory or motor and may involve small or large fibers, or both. Sensory impairment occurs in glove and stocking distribution and motor signs are not prominent.

The sensory symptoms reach up to knee level before the fingers are involved because of length dependent dying back process. Fiber dependent axonopathy results in increased predisposition in taller people.(43) DSPN is further classified into large fiber and small fiber neuropathy. Large fiber neuropathy is characterized by painless paresthesia with impairment of vibration, joint position, touch and pressure sensations, and loss of ankle reflex. In advanced stage, sensory ataxia may occur. Large fiber neuropathy results in slowing of nerve conduction, impairment of quality of life, and activities of daily living. Small fiber neuropathy on the other hand is associated with pain, burning, and impairment of pain and temperature sensations, which are often associated with autonomic neuropathy.

Nerve conduction studies are usually normal but quantitative sensory and autonomic

tests are abnormal. Small fiber neuropathy results in morbidity and mortality. Autonomic neuropathy is usually associated with DSPN; but diabetic autonomic neuropathy does not occur without sensory motor neuropathy.

PAINFUL DIABETIC NEUROPATHY

About 10% of diabetic patients experience persistent pain.(44) Pain in DN can be spontaneous or stimulus induced, severe or intractable. DN pain is typically worse at night and can be described as burning, pins and needles, shooting, aching, jabbing, sharp, cramping, tingling, cold, or allodynia. Some patients develop predominantly small fiber neuropathy manifesting with pain and paresthesia early in the course of diabetes that may be associated with insulin therapy (insulin neuritis).(45) It is of less than six months duration, symptoms are aggravated at night, and manifest more in feet than hands. Sometimes acute DN pain is associated with weight loss and depression and has been termed as diabetic neuropathic cachexia.(46) This syndrome commonly occurs in men, and can occur at any time in the course of both type I and type II diabetes. It is self limiting and responds to symptomatic treatment. In these patients amyloidosis, heavy metal toxicity, Fabry's disease, and HIV

CHRONIC PAINFUL DN

Chronic painful DN refers to painful neuropathy occurring over more than six months. These patients may develop tolerance to drugs and even get addicted. Neuropathy can develop even before the onset of clinically diagnosable diabetes mellitus, which is known as ''impaired glucose tolerance neuropathy''. Symptoms, electrodiagnostic studies, and reduced nerve fiber density are consistent with small fiber neuropathy although the changes are less prominent compared with their florid diabetic counterparts.(47)

The patients with undiagnosed painful neuropathies therefore should undergo a glucose tolerance test.(48) In patients with newly diagnosed diabetes, intermittent pain and paresthesia in distal lower limbs may suggest hyperglycaemic neuropathy, which improve as the hyperglycaemia is controlled. In DN, sensory loss renders the patient vulnerable to foot injuries, ulcers, and foot destruction. Foot care therefore is integral part of DN management.

DIABETIC AUTONOMIC NEUROPATHY

Diabetic autonomic neuropathy affects various organs of the body resulting in cardiovascular, gastrointestinal, urinary, sweating, pupils, and metabolic disturbances. Because of diversity of symptoms, autonomic DN often goes unnoticed by both the patient and the physician. Autonomic nerve involvement can occur as early as one year after the diagnosis of DM. Diabetic autonomic neuropathy usually correlates with severity of somatic neuropathy. It ranges from subclinical functional impairment of cardiovascular reflexes and sudomotor functions to severe cardiovascular, gastrointestinal, or genitourinary dysfunction. Orthostatic hypotension, resting tachycardia, and heart rate unresponsiveness to respiration are hallmark of diabetic autonomic neuropathy. Table 1 summarises clinical manifestations of autonomic diabetic neuropathy.

CLINICAL MANIFESTATIONS OF AUTONOMIC DIABETIC NEUROPATHY

CARDIOVASCULAR	GASTROIN TESTINAL	GENITOURINARY	MISCELLANEOUS
Tachycardia	Oesophageal	Erectile dysfunction	Hypoglycaemia

Exercise intolerance Painless myocardial infarction Orthostatic Hypotension	Dysfunciton Gastroparesis Diarrhoea Constipation Incontinence	Retrograde ejaculation Cystopathy Neurogenic bladder	Unawareness Miosis Argyll Robenson Pupil Heat intolerance Sweating disturbance, Gustatory sweating

Asymmetrical proximal diabetic neuropathy

It is also referred to as diabetic amyotrophy but should better be called as diabetic proximal neuropathy.(49) The other examples of proximal DN include thoracic radiculopathy and proximal diffuse lower extremity weakness that should be grouped under a single term diabetic polyradiculopathy, as these are diverse manifestations of same phenomena; root or proximal nerve involvement.

The weakness of pelvifemoral muscles occurs abruptly in a stepwise manner in the people above 50 years of age. Most of these patients have NIDDM but it is unrelated to the severity or duration of diabetes. The patients complain of pain in low back, hip, anterior thigh, typically unilateral but may be bilateral. Within days or weeks, the weakness and wasting of thigh and leg muscles follows. Knee reflex is reduced or absent. Numbness or paresthesia are minor phenomena. Weight loss occurs in more than half the patients.

Stepwise progression occurs over months. Pain subsides long before the motor symptoms improve, which may take months although mild to moderate weakness may persist indefinitely. In about 50% patients with diabetic proximal neuropathy, DSPN may coexist. Nerve biopsy shows multifocal nerve fiber loss suggesting ischaemic injury and perivascular infiltrate suggesting an immune mechanism.(39) Diabetic amyotrophy, which was initially thought to be attributable to metabolic changes, was later regarded as ischaemic because of

biopsy changes but now is considered to be attributable to immunological abnormality.(50)This has prompted intravenous immunoglobulins (IVIg) and cyclophosphamide therapy, which have resulted in rapid recovery.(51,52) In patients with proximal DN, especially if it is bilateral and the distal muscles are also involved; electrodiagnostic testing may show demyelinating features resembling chronic inflammatory demyelinating neuropathy (CIDP). In such patients apart from CIDP, monoclonal gammopathy and vasculitic neuropathy should also be considered. (51,53) Biopsy of obturator nerve has shown demyelination, inflammatory cell infiltrate, and immunoglobulin deposits in vasanervosa.(54)

Cerebrospinal fluid protein may be raised without lymphocytic pleocytosis. It is important to differentiate CIDP from lumbosacral radiculoplexoneuropathy attributable to ischaemic origin because of different therapeutic options. Diabetic patients are 11 times more vulnerable to develop CIDP(55) and they respond to immunomodulation by corticosteroid, plasma exchange, or IVIg.

Diabetic truncal neuropathy is associated with pain and paresthesia in T4–T12 distribution in chest or abdominal distribution. Bulging of abdominal wall may occur because of muscle weakness. It usually occurs in older patients with NIDDM. The onset may be abrupt or gradual and the patient may be confused with an intra-abdominal, thoracic disease, or herpes zoster. The symptoms may generally persist for months before gradually subsiding. Electromyography may show paraspinal denervation.

Limb neuropathies

There are two major mechanisms of limb neuropathies in diabetics: nerve infarction and entrapment. Nerve infarctions are associated with abrupt onset pain followed by variable

weakness and atrophy. As the primary pathology is axonal degeneration, the recovery is slow over a period of months. Median, ulnar, and peroneal nerves are most commonly affected.

Mononeuropathy

In diabetic patients, nerve entrapment is commoner than nerve infarction. The entrapment neuropathies have insidious onset, have characteristic electrodiagnostic features such as conduction block or segmental nerve conduction slowing in the entrapped segment of the nerve. Carpal tunnel syndrome is three times more common in diabetic patients than the normal population. The other entrapment neuropathies in diabetic patients are ulnar, radial, lateral femoral cutaneous nerve of thigh, peroneal and medial and lateral planter nerves.

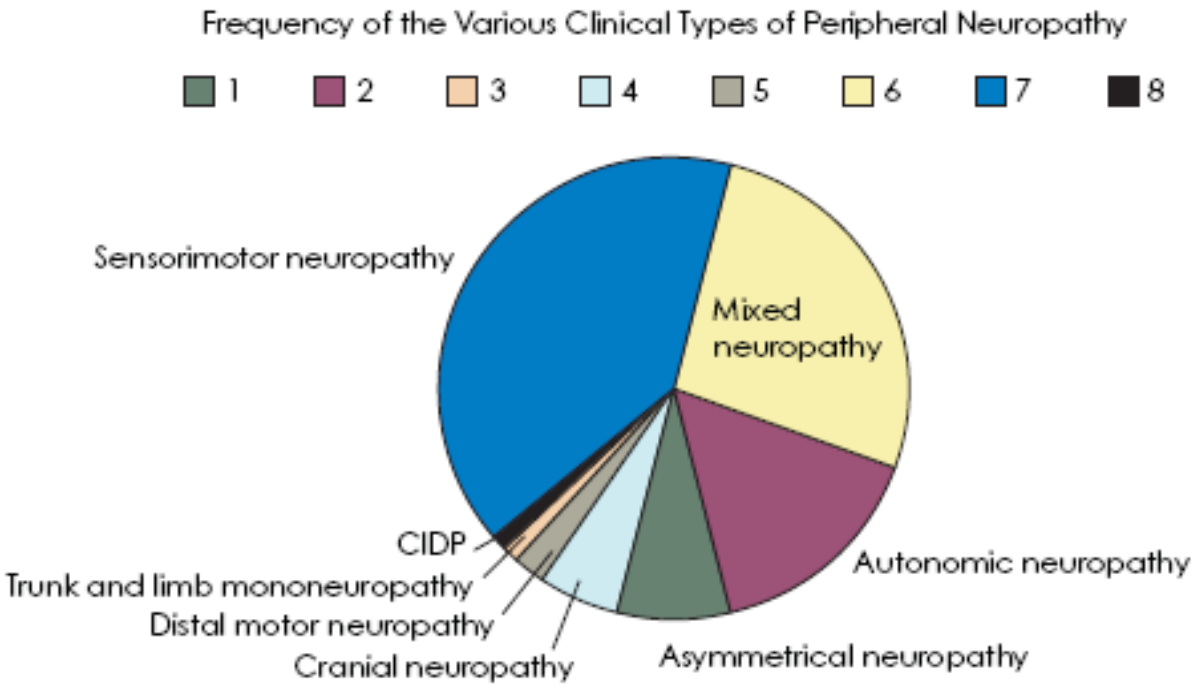
Cranial neuropathy

Cranial neuropathy in diabetic patients, most commonly involve the oculomotor nerve followed by trochlear and facial nerve in order of frequency. Third nerve palsy with pupillary sparing is the hallmark of diabetic oculomotor palsy and is attributed to nerve infarction. The pupillary fibres are peripherally located; therefore escape in diabetic oculomotor palsy.

Multiple neuropathies

Multiple neuropathies refer to the involvement of two or more nerves. As in mononeuropathy the onset is abrupt in one nerve and occurs earlier than the other nerves, which are involved sequentially or irregularly. Nerve infarctions occur because of occlusion of vasa nervosum and should be differentiated from systemic vasculitis.

e 1. Various clinical types of peripheral neuropathy



DIAGNOSIS OF DN

For diagnosis of DN, bedside examination should include assessment of muscle power, sensations of pinprick, joint position, touch, and temperature. Vibration test should be done by tuning fork of a 128 Hz. For touch sensation mono filament of 1 g is recommended. Sensory examination should be performed on hands and feet bilaterally. In old age (.70 years) vibration and ankle reflex may be reduced normally and considered abnormal if these are absent rather than reduced in a patient with DN.

Quantitative sensory testing may be used as ancillary test but is not recommended for routine clinical practice.(55) The autonomic function tests commonly used in DM are based on blood pressure and heart rate response to a series of manoeuvres. Specific tests are used for

evaluating gastrointestinal, genitourinary, sudomotor function, and peripheral skin blood flow. Nerve biopsy may be useful for excluding other causes of neuropathy. Skin biopsy has been used when all other measures are negative in the diagnosis of small fibre neuropathy for quantification of protein gene product 9.(38), which is a panaxonal marker.(56)

Diabetes as a cause of neuropathy is diagnosed by exclusion of other causes in patients who present with painful feet and have impaired glucose tolerance test.(46) Recently confocal corneal microscopy in the assessment of diabetic polyneuropathy has been reported. In confocal microscopy, the cornea is scanned and the images of Bowman's layer, which contains a rich nerve plexus are examined for nerve fibre density, length, and branch density. These parameters are significantly reduced in DN and correlated with the severity of neuropathy. Because of its noninvasive nature, confocal microscopy may have great potential in assessing nerve structure in vivo without need for nerve biopsy.(57)

The American Academy of Neurology recommends that DN is diagnosed in presence of somatic or autonomic neuropathywhen other causes of neuropathy have been excluded.(58) About 10% of diabetic patients may have other causes of neuropathy. DN cannot be diagnosed without careful examination, because DN may be asymptomatic in a number of patients. At least one of each of the five criteria is needed: symptoms, signs, electrodiagnostic tests, quantitative sensory, and autonomic testing.(58) This may be necessary in research protocols. However. in clinical practice two of five criteria have been recommended.(59) Underdiagnosis or misdiagnosis of DN in clinical practice has been emphasised in the GOAL A1C study in which 7000 patients were evaluated and only 38% with mild and 61% with severe neuropathy were detected. This study highlighted the importance of education of physician in diagnosing

DN.(60)

Nerve conduction studies

Motor nerve conduction, F response, and sensory nerve conduction studies are important methods of documentation and follow up of nerve functions in DN. Motor nerve conduction studies are affected in a small subset of DN (large fibre neuropathies). Even in large diameter fibre neuropathy nerve conduction velocity (NCV) is insensitive for many pathological changes known to be associated with DN. The nerve conduction changes are non-specific and key to the diagnosis lies in excluding other causes or those superimposed on DN. Entrapment neuropathies are common in diabetic patients and result in unilateral NCV changes, especially across the entrapped segment of the nerve.

The commonest abnormality in diabetes is reduction in the amplitude of motor or sensory action potentials because of axonopathy. Pronounced slowing of NCV suggests demyelinating neuropathy, which is rarely associated with diabetes; therefore pronounced slowing of NCV in a diabetic patients should prompt investigations for an alternative diagnosis. However, the likelihood of CIDP occurring in diabetic patients is 11 times higher than the normal population.(54)The NCV is gradually diminished in DN, with estimates of a loss of about 0.5 m/s/y.(61) In a study on 133 patients with newly diagnosed IDDM followed up for 10 years it was shown that NCV diminished in six nerves evaluated.

The maximum deficit was 3.9 m/s in sural nerve (48.3–44.4 m/s) whereas peroneal motor NCV was reduced by 3 m/s over same period.(62) A similar slow rate of decline was shown in DCC trial. A simple rule is that a 1% fall in Hb1Ac improves the conduction velocity by about 1.3 m/s.(61) There is however strong correlation between myelinated fibre density and

whole sural nerve amplitude.(63)

PATHOGENESIS

The cause of DN though remains unknown but ischaemic and metabolic components are implicated. Hyperglycaemia induces rheological changes, which increases endothelial vascular resistance and reduces nerve blood flow. Hyperglycaemia also causes depletion of nerve myoinositol through a competitive uptake mechanism. Moreover, activation of polyol pathway in the nerve through enzyme aldose reductase leads to accumulation of sorbitol and fructose in the nerve and induces nonenzymatic glycosylation of structural nerve proteins.

Hyperglycaemia also induces oxidative stress. Activation of protein kinase C has been linked to vascular damage in DN. These changes result in abnormal neuronal, axonal, and Schwann cell metabolism, which result in impaired axonal transport. Direct measurement of glucose, sorbitol, and fructose in nerves of diabetic patients showed correlation with the severity of neuropathy. Endoneural hypoxia is produced by increased vascular resistance and reduced blood flow in the nerve. Hypoxia leads to further capillary damage, which in turn aggravates disturbance in axonal transport and reduced Na-K ATPase activity leading to axonal atrophy and impairment of nerve conduction. Unfortunately the basic research in DN has focused on carbohydrate metabolism; whereas amino acids, electrolytes, and lipid biochemical changes, which are associated with DM, have not been investigated with same vigour.

MANAGEMENT OF DIABETIC NEUROPATHY

Disease modification The treatment of DN is aimed at preventing the progression of neuropathy and providing symptomatic relief. Glycaemic control The relation between hyperglycaemia and development of severity of neuropathy has been shown in retrospective

and prospective studies. A classic study on 440 diabetic patients who were followed up over 25 years, showed an increase in clinically detectable DN from 12% at the time of diagnosis of diabetes to about 50% after 25 years and those with poorest diabetic control had the highest prevalence.7 Significant effect of intensive insulin therapy on prevention of DN were shown in DCC trial.(64)

The prevalence rate for clinical or electrophysiological evidence of neuropathy was reduced by 50% in those treated by intensive therapy during five years. Only 3% of the primary prevention cohort treated by intensive insulin therapy showed minimal signs of DN compared with 10% of those treated with conventional regimen. In the secondary prevention cohort, intensive insulin therapy reduced the prevalence of DN by 50% (7% compared with 16%) in intensive and conventional groupsrespectively. The results of DCC trial support the need for strict glycaemic control.(63) In the UK prospective diabetes study, control of blood glucose was associated with improvement in vibration perception.(65) Reduction of odds ratio for the development of autonomic neuropathy to 0.32 was reported in the Steno trial.(66)

Association of vascular risk factors with DN The risk factors for development of DSPN in 1172 patients with type I DM was studied over 7.3 (SD 0.6) years. Clinical evaluation, quantitative sensory testing, autonomic function tests, serum lipids and lipoprotein, glycosylated Hb, urinary albumin excretion rate, and serum creatinine were measured in 276 patients. In this study 23.5% developed neuropathy, which apart from the glycaemic control was related to potentially modifiable cardiovascular risk factors including raised serum triglyceride, body mass index, smoking, and hypertension.(67) A stepwise progressive study of treatment of type II diabetic patients with hypotensive drugs, angiotensin converting enzyme inhibitors, calcium channel blockers, hypoglycaemic agents, aspirin, hypolipidaemic agents,

and antioxidants. This study argues for the multifactorial nature of neuropathy and need for managing multiple metabolic abnormalities.(66)

MATERIALS AND METHODS

Inclusion criteria

1. Diabetic patients referred to Neurology O.P.D for symptoms of peripheral neuropathy were assessed and those with clinically demonstrable Peripheral Neuropathy (DPN) were screened.
2. Patients who were admitted in General Medical and Neurology ward with symptoms related to diabetic neuropathy were also selected for this study.

Exclusion Criteria

1) Patients with a family history of inherited neuropathies, occupational or environmental history of heavy metal exposure, history of lumbar or cervical radiculopathy as well as patients using medications which could cause polyneuropathy were excluded.

2) Patients with nutritional deficiencies, collagen vascular disease, malignancies, tabes dorsalis, toxin exposure (e.g., alcohol, occupational toxins, vitamin B6, and medications known to be associated with peripheral neuropathy), hypothyroidism, pernicious anemia, dysproteinemias, amyloidosis, AIDS, spinal cord disease, and cauda-equina syndrome were excluded.

Methodology

This study was done over a period of two years - between March 2007 and February 2009. 156 patients were selected for study, out of the 207 patients screened. The study protocol was approved by the Ethics Committee of the Government General Hospital and all subjects gave their informed consent prior to the study.

Assessment of neuropathy: Determination of whether a patient had neuropathy was based on review of the medical record, neurologic tests including bed side autonomic function tests, nerve conduction (NC) abnormalities.

Three approaches were used to determine whether a neurologic abnormality was due to diabetes mellitus or to another cause: (1) the patient's history and the medical record were analyzed (2) additional tests were performed if needed; and (3) judgments were made as to whether the findings were typical of diabetic neuropathy.

Systematic questioning, including family history of nondiabetic peripheral nerve disease and the presence of toxic, metabolic, mechanical, and vascular causes of nerve disease, was conducted.

All patients underwent tests for complete blood count and routine serum chemistry including lipid profiles as well as tests for thyroid hormones, HbA1C and E.C.G.

Standardization of examining methods.

History and physical examination were included (refer proforma). In the sensory examination ambiguous findings were considered negative. The response to each test were considered normal, decreased, or absent. The instruments used were **1)** a disposable pin for

pain evaluation, **2)** a cotton tip for light touch, **3)** a 128 Hz tuning fork for vibration sensation, and **4)** finger and toe movements with immobilization of the proximal joint to evaluate joint position. The sites examined included the distal toe and distal finger.

The motor system was examined manually for individual muscles with a previously used validated grading system. Mechanical devices to evaluate strength may not add precision because they emphasize groups of muscles and because the condition of the joints and periarticular tissues frequently are abnormal in diabetes. Muscle testing is of limited value in assessing mild diabetic neuropathy.

Weakness appears late and usually only involves intrinsic foot muscles and ankle dorsiflexors; more proximal muscles are only involved in more severe cases of diabetic polyneuropathy. Reflexes were classified as **1)** present and active, **2)** present and hypoactive, and **3)** absent. Autonomic function tests were done for symptomatic patients. More specific staging of diabetic polyneuropathy (DPN) described by Dyck and Dyck**(27)**: (NO, no neuropathy; N1, asymptomatic neuropathy without (N1a) or with (N1b) findings on neurological examination; N2, symptomatic; N3, disabling) were applied to all patients.

Electrodiagnostic Measures-Standardization

The RMS system was used. Recommended filter settings (approximate values) were 20-3,000 Hz bandpass for sensory studies, 2-10,000 Hz bandpass for motor studies, and 20-10,000 Hz bandpass for needle electromyography.

Protocol for electrodiagnostic test

A. Motor nerve conduction studies

1. Unilateral studies of ulnar and median nerve including F waves in the upper

limb

2. Unilateral studies of peroneal and posterior tibial nerve including F wave in the lower limb

3. Measurement of muscle action potential amplitude and latency at each site of stimulation and calculation of segmental conduction velocity

B. Sensory nerve conduction studies

1. Unilateral studies of ulnar and median nerve in the upper limb

2. Unilateral studies of either sural or medial plantar nerve in the lower limb

3. Measurement of nerve action potential amplitude and latency at each site of stimulation and calculation of segmental conduction velocity

C. Studies of additional nerves were undertaken to characterize abnormalities based on the distribution of clinical symptoms or signs.

D. Facial nerve conduction was done in all patients (even those without clinial involvement)

E. The normal values for representative nerve conduction values at various sites of stimulation were derived at after analyzing the NC of 30 age matched patients who came to Neurology OPD for complaints other than neuropathy.

MOTOR NERVE CONDUCTION

Nerve	Distal Latency (ms)	Amplitude (mv)	CV (m/s)	F-Wave Latency (ms)
Median	<4.2	>4	>49	<31
Ulnar	<3.4	>4.5	>49	<32
Tibial	<6.0	>3.5	<40	<56
Peroneal	<6.0	>2.2	<40	<56
Facial	<1.1	>1.4	-	-

SENSORY NERVE CONDUCTION

Nerve	Amplitude (uV)	CV (m/s)
Median	>5	-
Ulnar	>5	-
Sural	>6	>40

RESULTS

Clinical Characteristics of Study Subjects

The mean age of the diabetics was 53.0 ± 12.4 years. Their ages ranged from 31–67years. The duration of diabetes varied from newly detected to more than 20 years with a mean duration of 7.5 ± 4.2 years. Of the 156 patients 92 were males (59.3%) and 64 females (41.2%).

The highest proportion among the diabetics was in the age group of 50–59 years with a frequency of 34.2%.

Characteristics (N=156)	Diabetics
Number (Male / Female)	92/64
Age (Years) (Mean, SD)	53.0 $\pm$ 12.4
Duration of Diabetes Mellitus (Years)	7.5 $\pm$ 4.2
Mode of Treatment (%)	
OHA	59.6%
Insulin	33.8%

Types of Diabetic Peripheral Neuropathy

Sensorimotor polyneuropathy was the most common form of peripheral neuropathy, with a frequency of 47.4%, followed by mixed type peripheral neuropathy (26.7%) and Autonomic Neuropathy (31.4%).

Grades of Peripheral Neuropathy

The different stages of neuropathy using the Dyck grading system are shown in Table .

This was analyzed based on gender among the diabetics. Thirty-eight subjects—8 male diabetics and 7 female diabetics (9.6%)—had stage-0 neuropathy, while 39—21 male and 18 female—diabetics (25%) had stage 1. There was no significant difference between males and females with severity of peripheral neuropathy.

Grades of diabetic-peripheral neuropathy by gender(27)

Grades	Male Diabetics	Female Diabetics
Stage N 0	8	7
Stage N 1	21	18
Stage N2	51	34
Stage N 3	12	5

Most of the patients were type II, (88.2%) while 16 were type I (11.8%). The mean duration of DM was 7.5 ± 4.2 years. Oral hypoglycemic agents (OHA) were the treatment used by 81 patients (59.6%), followed by insulin 46 (33.8%), diet 5 (3.7%) and combined OHG and insulin in 4 (2.9%). Poor glycemic control was found in 87 patients (64%) while 49 (36%) were well controlled.

Eigty-nine (57.3%) patients were hypertensive while hyperlipidemia was found in 48 (30.7%) and a history of smoking in 43 (27.3%). Normal NCS were found in 55 patients (35%).

Abnormal NCS were found in 101 patients (65%). Nerve conduction abnormalities in symptomatic patients were significantly related to poor glycemic control. Seventy-one (81.6%) poorly controlled patients had abnormal NCS as compared to 16 (18.4%) well controlled

patients (P <0.001). Long duration of DM was also strongly related to abnormalities in NCS, the mean duration of DM in patients with NCS abnormalities was 7.4 years as compared to 3.1 years in those with normal NCS (P <0.001). Abnormal NCS were also significantly associated with insulin use, 32 (69.6%) of those on insulin showed abnormal NCS compared to 14 (30.4%) who showed normal NCS.

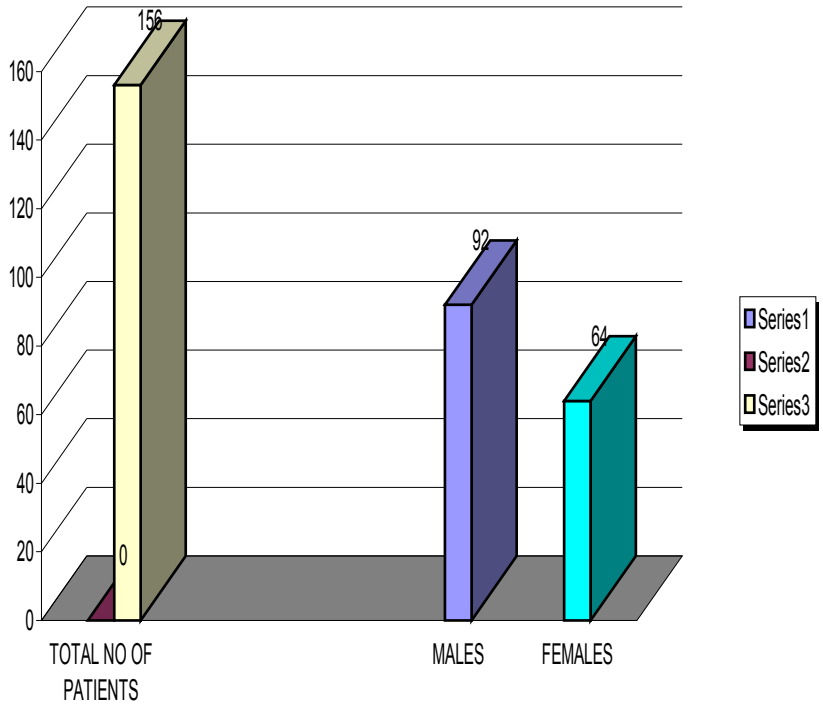
There was no significant relation between abnormal NCS and patients age (p0.4), sex (p0.7), type of DM (p0.1), hypertension (p0. 5), hyperlipidemia (p0.23) or smoking (p0.13)

SEX DISTRIBUTION

A total of 156 patients fulfilled the criteria were included in the study. There were 92(59%) males and 64(41%) females among 156 diabetic patients.

TABLE - 1

Total No. of patients	156
Male	92 (59%)
Female	64 (41%)

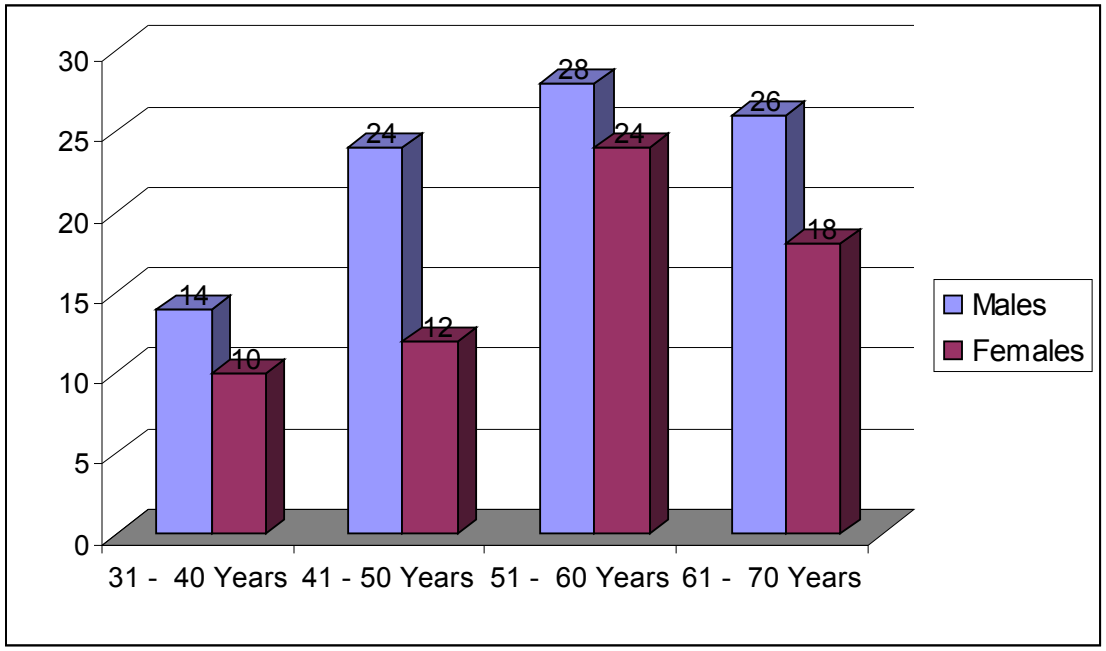

156
160
140
120
100
92
80
64
60
40
20
0
0
TOTAL NO OF PATIENTS
MALES
FEMALES
Series1
Series2
Series3

AGE AND SEX DISTRIBUTION:

Males predominated in all age groups. Around two thirds of males (85%) were in the age group between 40 and 70 years and two-third of females (84%) were in the age group between 40 and 70 years. The Table 2 shows age distribution based on sex.

TABLE - 2

AGE AND SEX DISTRIBUTION	MALES	FEMALES
31 - 40 Years	14(15%)	10(16%)
41 - 50 Years	24(26%)	12(19%)
51 - 60 Years	28(30%)	24(37%)
61 - 70 Years	26(28%)	18(28%)

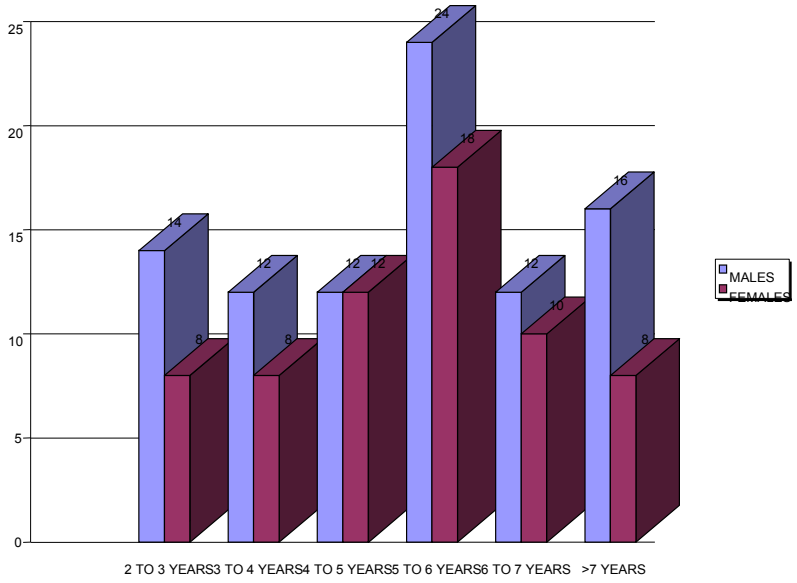


DURATION OF DIABETES

Among the patients studied the duration of diabetes more than 5 years in 69% male patients and 73% of female patients

TABLE - 3

DURATION OF DIABETES	MALES	FEMALES
2 TO 3 YEARS	14(15%)	8(13%)
4 TO5 YEARS	24(26%)	20(32%)
6TO 7YEARS	28((30%)	26(40%)
8 TO 9YEARS	12(13%)	10(16%)
>9YEARS	16(17%)	8(13%)



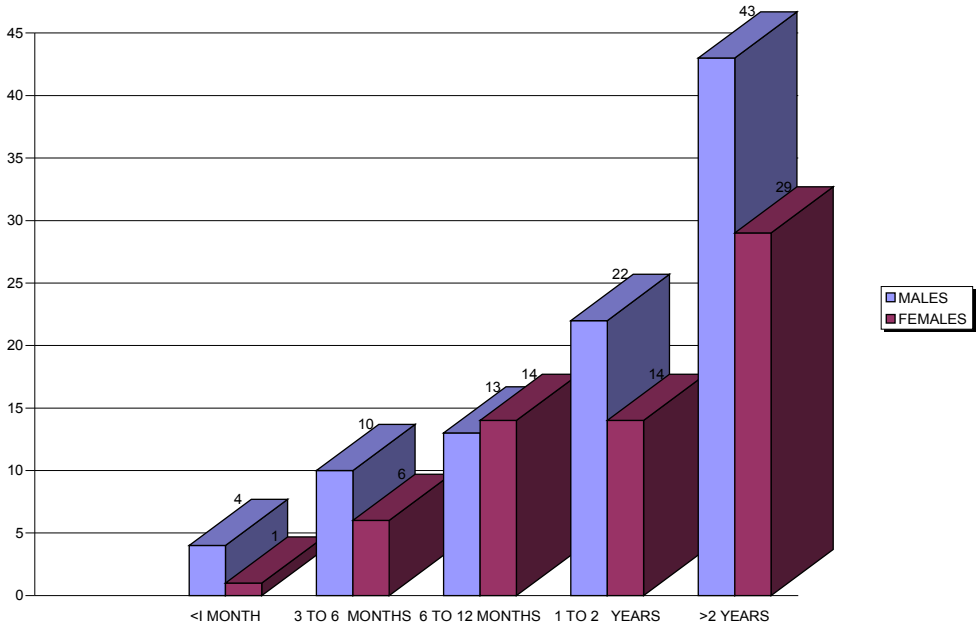
DURATION OF SYMPTOMS

Among the patients studied about two thirds (78% of males and 57% females) had diabetic neuropathic symptoms in the duration of 6 months to more than 2 years as shown in

table 4.

TABLE- 4

duration of symptoms	MALES	FEMALES
<3MONTHS	4(4%)	1(1%)
3 TO 6 MONTHS	10(11%)	6(9%)
6 TO 12 MONTHS	13(14%)	14(22%)
1 TO 2 YEARS	22(24%)	14(22%)
>2 YEARS	43(47%)	29(45%)



CLINICAL SYMPTOMS

TABLE - 5

CLINICAL SYMPTOMS	MALE	FEMALE	TOTAL
NUMBNESS OF HANDS AND FEET	63(63%)	46(72%)	*109(70%)*
PINS AND NEEDLES SENSATIONS	33(36%)	42(66%)	86(55%)
BURNING FEET	26(28%)	18(28%)	44(28%)
UNSTEADINESS IN DARKNESS	42(46%)	34(53%)	76(49%)

AUTONOMIC SYMPTOMS

TABLE - 6

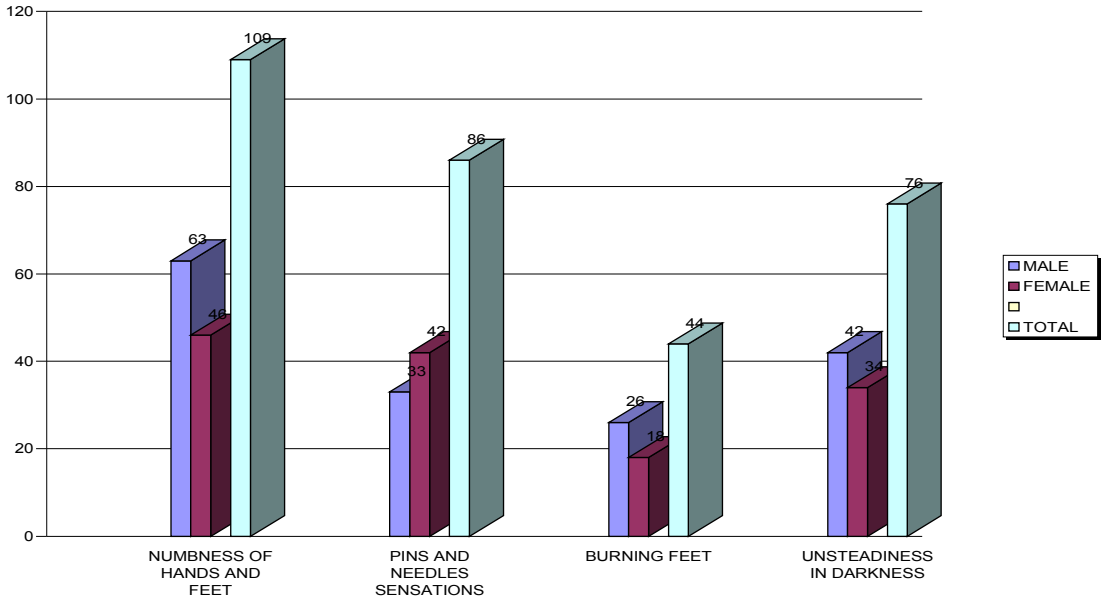
AUTONOMIC SYMPTOMS	
POSTURAL GIDDINESS	27(17%)
SWEATING DISTURBANCES	13(8%)
BLADDER AND BOWEL DISTURBANCES	12(7%)
ERECTILE DYSFUNCTION	32(20%)
TOTAL	84(54%)

WEAKNESS

TABLE - 7

WEAKNESS	PROXIMAL	DISTAL
UPPER LIMB	3	36

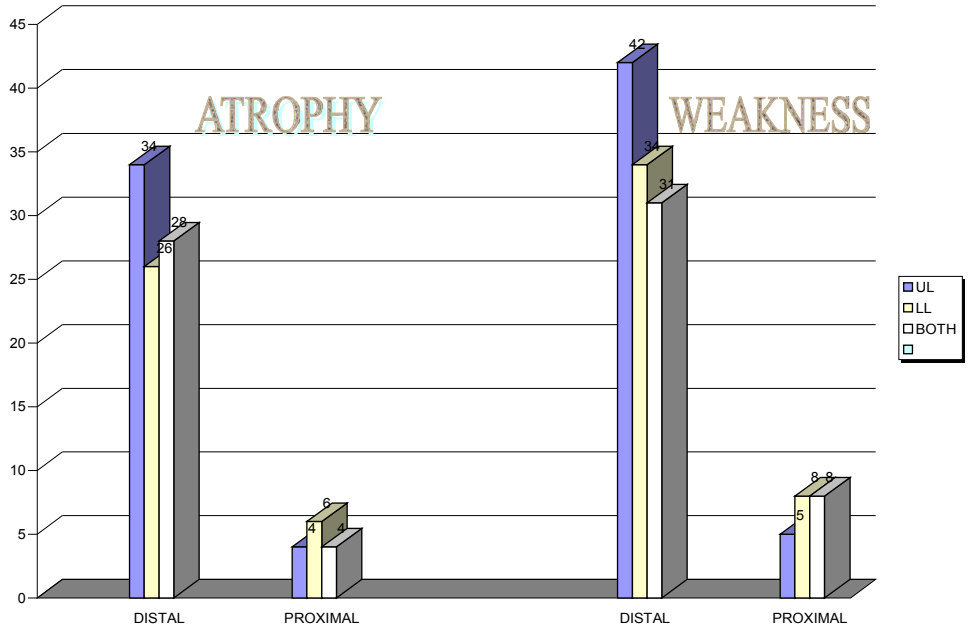
LOWER LIMB	6	28
BOTH UPPER AND LOWER LIMBS	3	31



SPINOMOTOR SYSTEM

TABLE - 8

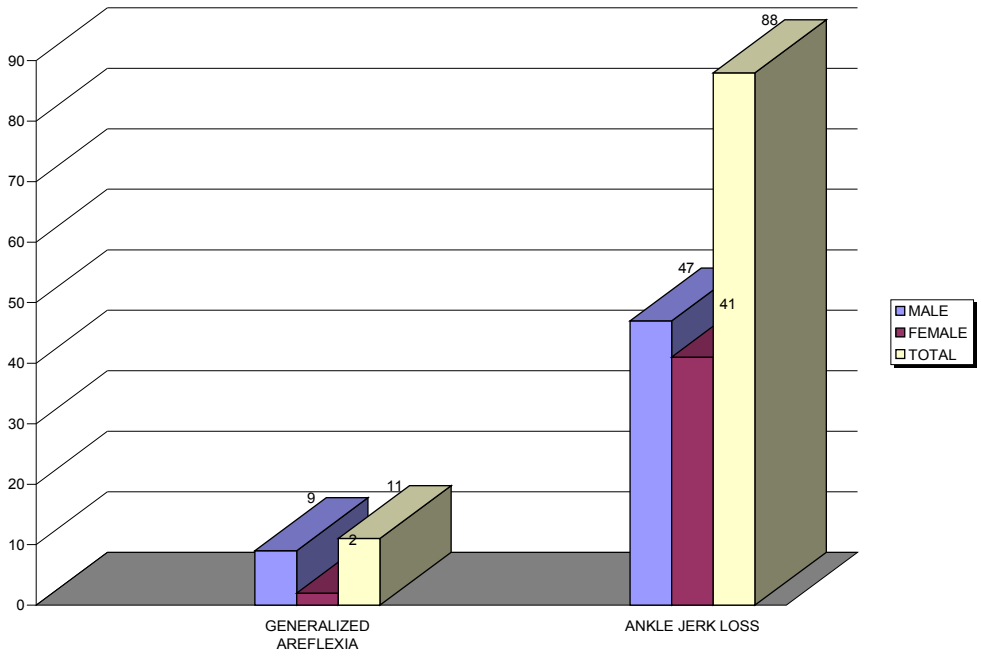
SPINOMOTOR SYSTEM			
ATROPHY	UL	LL	BOTH
DISTAL	34	26	28
PROXIMAL	4	6	4
WEAKNESS			
DISTAL	42	34	31
PROXIMAL	5	8	8



REFLEXES

TABLE - 9

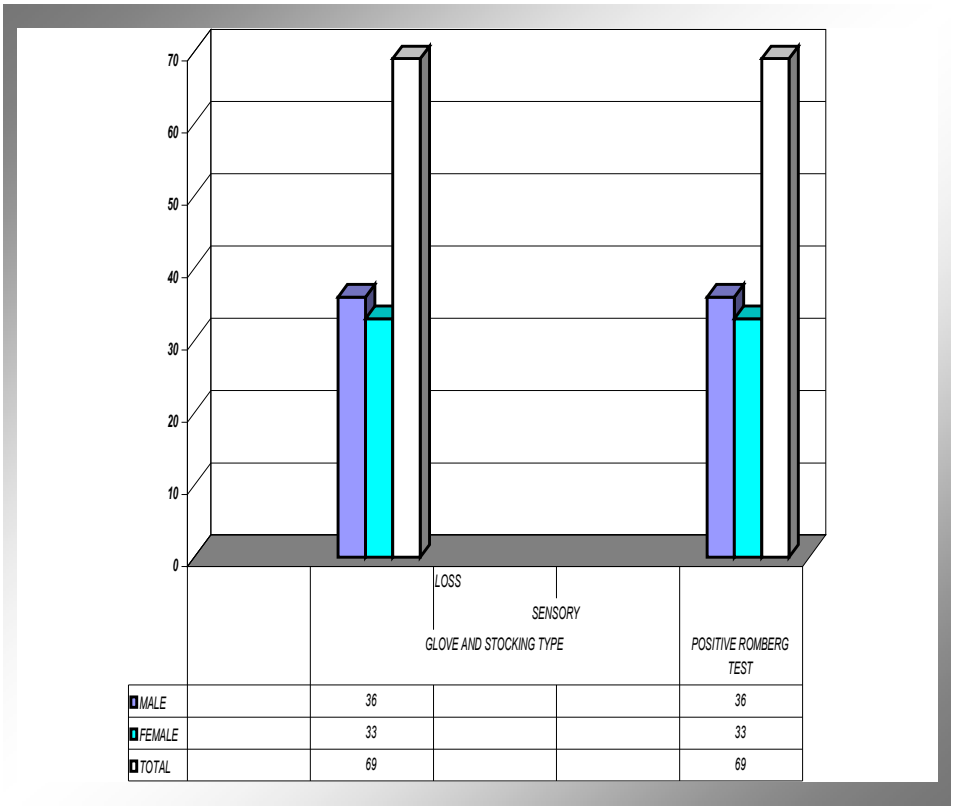
REFLEX LOSS	TOTAL
GENERALIZED AREFLEXIA	9 (6%)
ANKLE JERK LOSS	87(56%)



SENSORY SIGNS

TABLE - 10

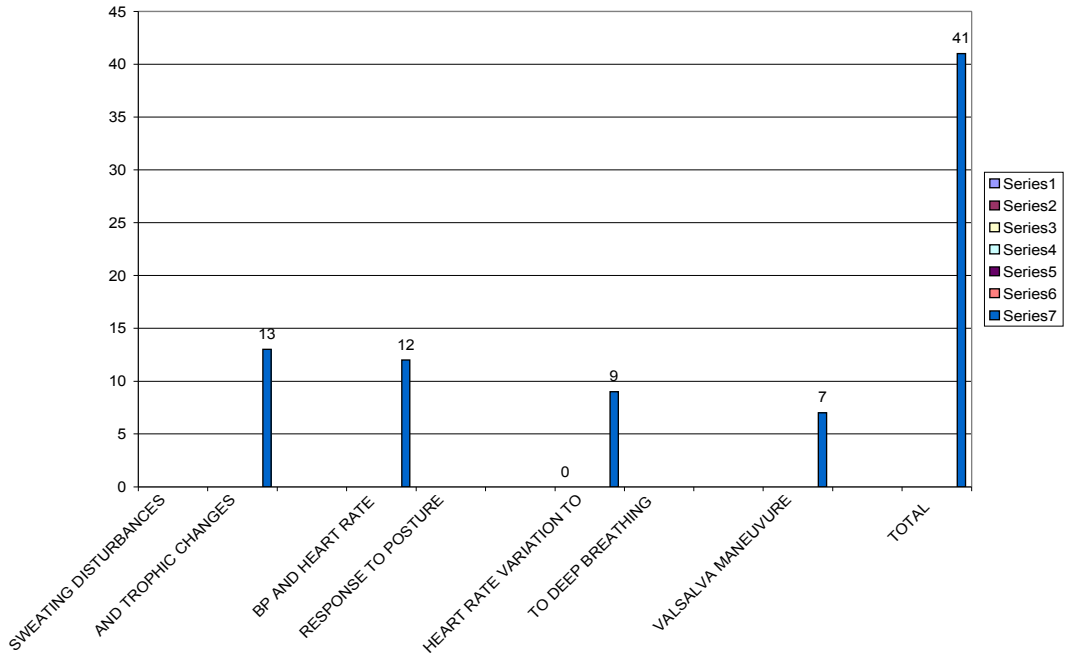
	MALES	FEMALES	TOTAL
GLOVE AND STOCKING TYPE SENSORY LOSS	36(39%)	33(51%)	69(44%)
POSITIVE ROMBERG TEST	36(39%)	33(51%)	69(44%)



AUTONOMIC FUNCTIONS

TABLE - 11

AUTONOMIC FUNCTIONS	
SWEATING DISTURBANCES AND TROPHIC CHANGES	13(8%)
BP AND HEART RATE RESPONSE TO POSTURE	12(8%)
HEART RATE RESPONSE TO DEEP BREATHING	9(6%)
VALSALVA MANEUVURE	7(4%)
TOTAL	41(26%)

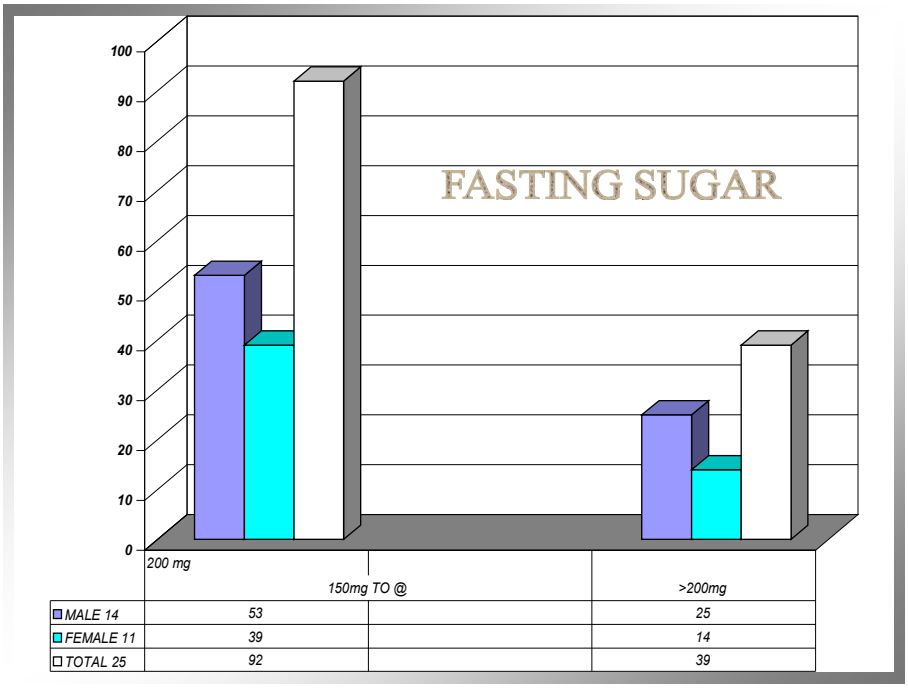


BLOOD SUGAR

FASTING

TABLE 12.

FASTING	MALE	FEMALE	TOTAL
100 mg TO 150mg	14(15%)	11(17%)	25(16%)
150mg TO 200mg	53(58%)	39(61%)	92(59%)
>200mg	25(27%)	14(22%)	39(25%)

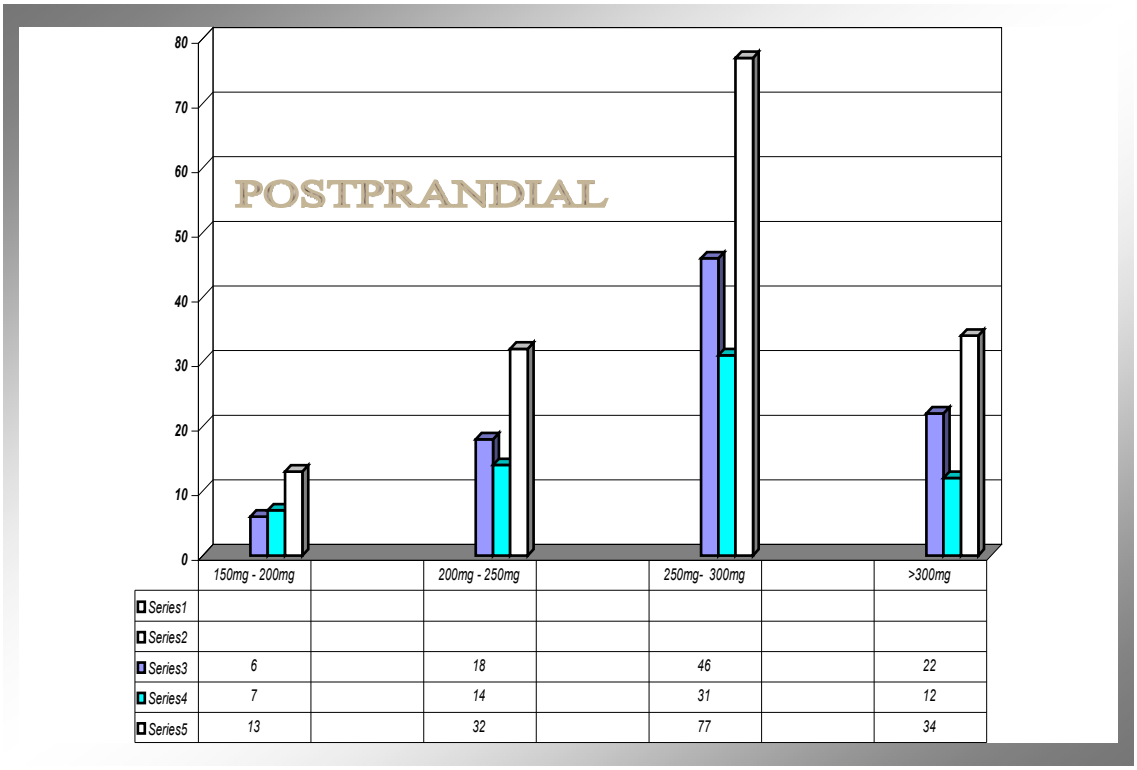


BLOOD SUGAR

POST-PRANDIAL

TABLE - 13

POSTPRANDIAL	MALES	FEMALES	TOTAL
150mg TO 200mg	6(6%)	7(11%)	13(8%)
200mg TO 250mg	18(19%)	14(22%)	32(20%)
250mg TO 300mg	46(50%)	31(48%)	77(49%)
>300mg	22(24%)	12(19%)	34(22%)

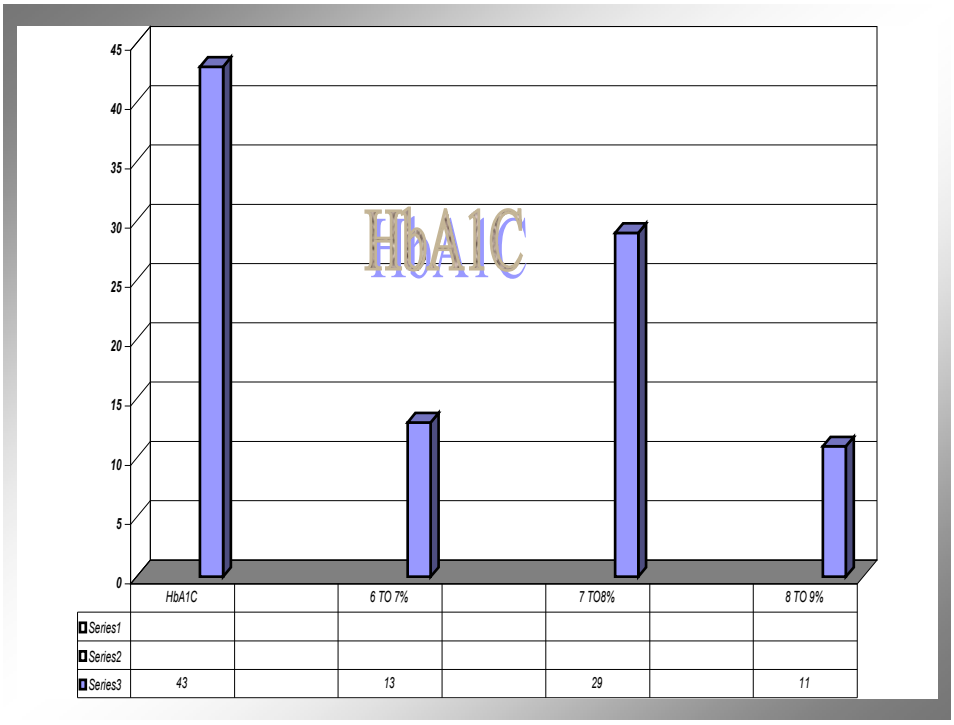


HbA1C

TABLE - 14

HbA1C	43(28%)
6 TO 7%	13(8%)

7 TO8%	29(19%)
8 TO 9%	11(7%)



SUMMARY OF NERVE CONDUCTION STUDIES

DISTAL MOTOR LATENCY

Nerves	Total No. Of Patients	Normal	Increased	No response	Mean ± SD	Range
Median	156	94	46 (4†)	16	4.0 ± 1.8	3.1- 12.8
Ulnar	156	108	32 (2†)	16	3.8 ± 1.0	2.6-9
Tibial	148	82	47	19	5.6 ± 1.5	3.6-13.7
Peroneal	152	86	46	20	5.5± 1.2	3.9-9.5
Facial	156	147	9 (5†)	-		

DISTAL MOTOR AMPLITUDE

Nerves	Total No. Of Patients	Normal	Decreased	No response	Mean ± SD	Range
Median	156	38	102 (32†)	16	2.6 ± 1.8	0.2- 8.8
Ulnar	156	42	98 (30†)	16	3.0 ± 2.1	0.5-9.1
Tibial	148	37	92	19	2.3 ± 1.5	0.3-6.5
Peronea l	152	37	95	20	1.8 ± 1.3	0.3-7.4
Facial	156	151	5 (1†)	-		

MOTOR CONDUCTION VELOCITY

Nerves	Total No. Of Patients	Normal	Decreased	No response	Mean ± SD	Range
Median	156	104	36 (3†)	16	48.8 ± 7.1	19.0-59.0
Ulnar	156	108	32 (2†)	16	48.3 ± 8.8	8.9-54.2
Tibial	148	90	39	19	38.4 ±4.0	20.4-43.0
Peronea l	152	89	43	20	39.9 ± 2.1	23.0-42.0

F WAVES LATENCY

Nerves	Total No. of Patients	Normal	Decreased	No Response	Mean ±SD	Range
Median	156	88	52 (10†)	16	33.5 ± 3.9	25.0-75.0
Ulnar	156	98	42 (12†)	16	33.8 ± 2.3	20-66
Tibial	148	53	76	19	62.5 ± 4.5	34.0-45.2
Peroneal	152	66	40	46	63.2 ± 4.9	50.0-137.0

SENSORY AMPLITUDE

Nerves	Total No. Of Patients	Normal	Decreased	No response	Mean ± SD	Range
Median	156	75	66 (11†)	4	12.0 ± 4.2	1.8-20.0
Ulnar	156	86	58 (8†)	4	11.4 ± 3.1	1-15.0
Lower Limb	137	37	84	16	4.5 ± 2.6	1.3-15.7

SENSORY CONDUCTION VELOCITY (SURAL)

Nerves	Total No. Of Patients	Normal	Increased	No response	Mean ± SD	Range
Lower Limb	137	74	47	16	35.7 ± 4.4	26.0-49.0

† PATIENTS WITH NO UPPER LIMB SYMPTOMS

MOTOR NERVE CONDUCTION

Nerve	No. of nerves studied	No.(%) of patients with findings of focal demyelination	Conduction Block	Temporal Dispersion
Median	156	46	5	2
Ulnar	156	32	3	1
Peroneal	152	46	3	21
Tibial	148	47	1	8

CLINICAL TYPES OF DIABETIC NEUROPATHIES

TYPES OF NEUROPATHIES	MALES	FEMALES	TOTAL
SYMMETRIC SENSORIMOTOR	52(26.9%) 26(†) 2(††)	42(21.1%) 23(†) 4(††)	94 (48.0%) 49 (31.4%) 6 (3.8%)
PAINFUL DISTAL SESORY	20(12.8%) 19(†)	17(10.8 %) 15(†)	37(23.6%) 34(21.9%)
DIABETES WITH AIDP	4(2.5%)	1(0.6%)	5(3%)
DIABETES WITH CIDP	6(3.8%)		6(3.8%)
LUMBOSACRAL RALICULO PLEXONEUROPATHY	2(1.3%)	1(0.6%)	3(2%)
MONONEURITIS MULTIPLEX	3(2%)		3(2%)
CRANIAL NEUROPATHIES	5(3%)	3(2%)	8(5%)

† WITH AUTONOMIC INVOLVEMENT

† † WITH CARPAL TUNNEL SYNDROME

FIG 1.

A PATIENT WITH MEDIAN SENSORY NERVE CONDUCTION

NORMAL

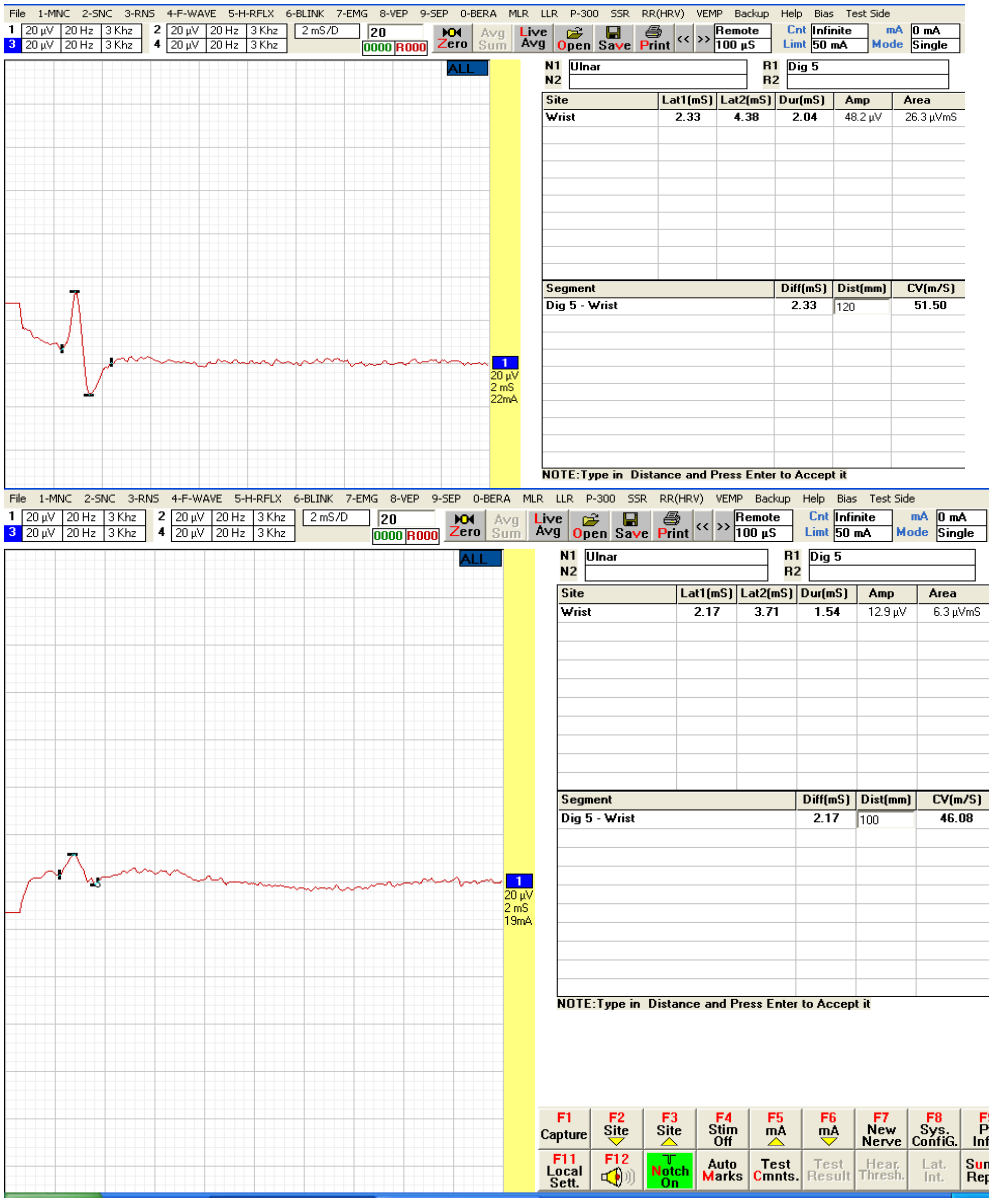


FIG 2.

A DIABETIC WITH MEDIAN NERVE CONDUCTION STUDY SHOWING REDUCED "CMAP" AMPLITUDE

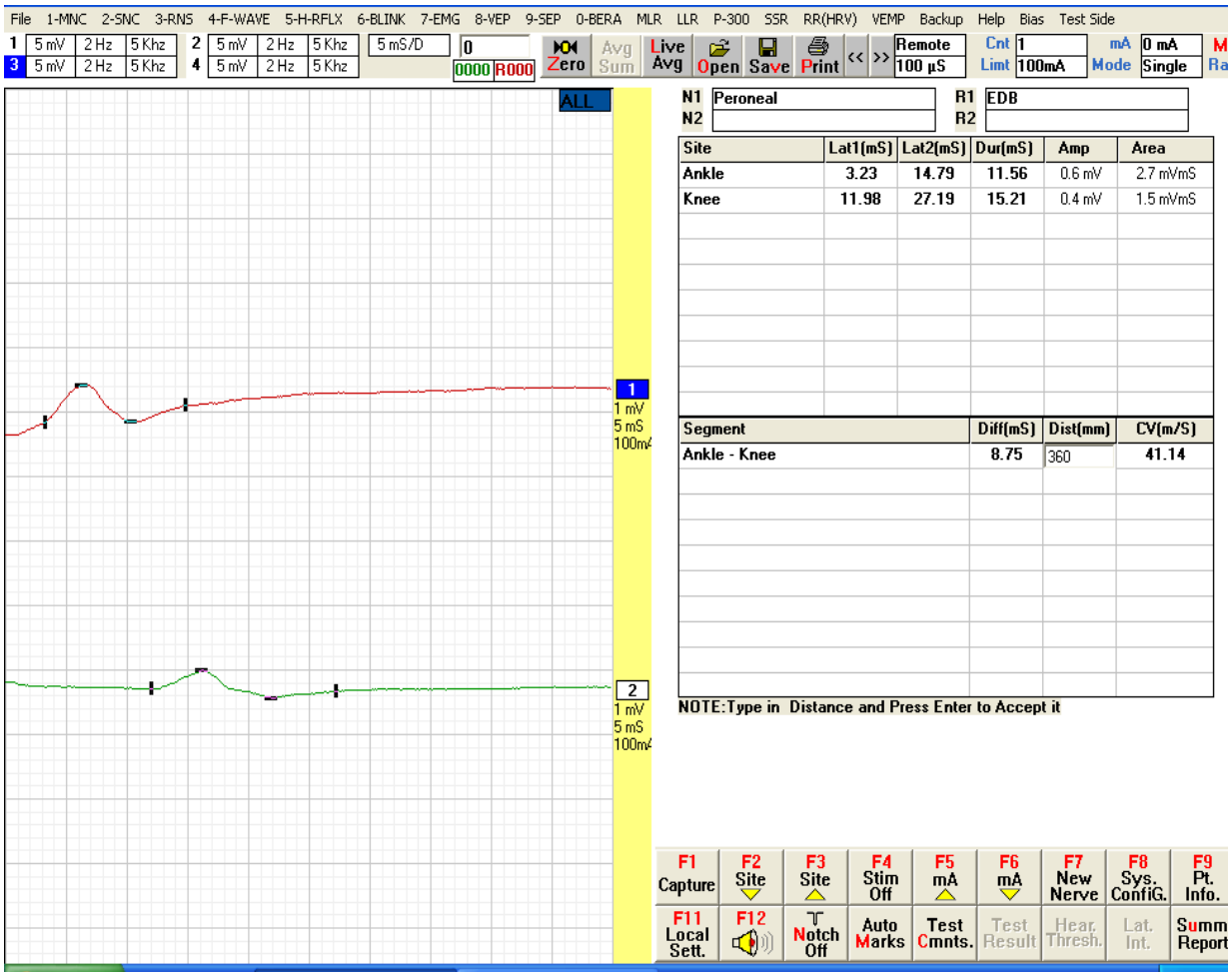
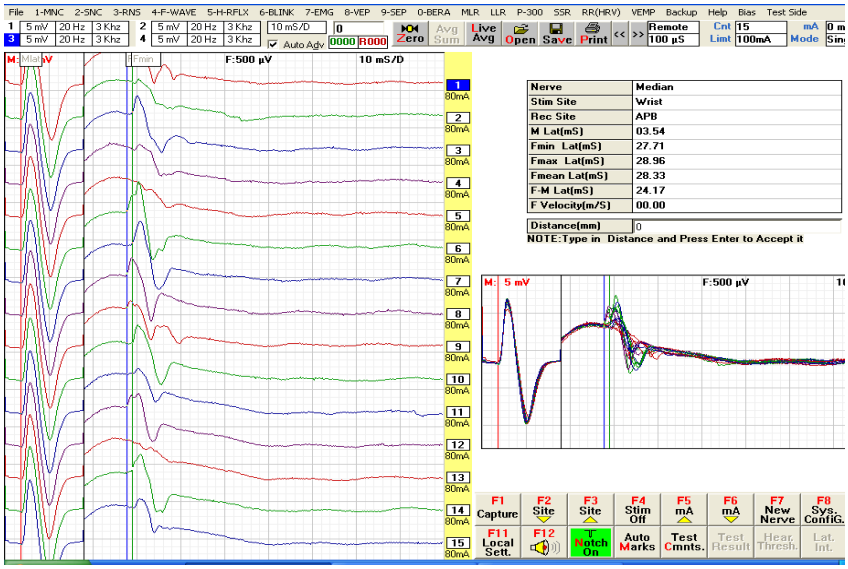


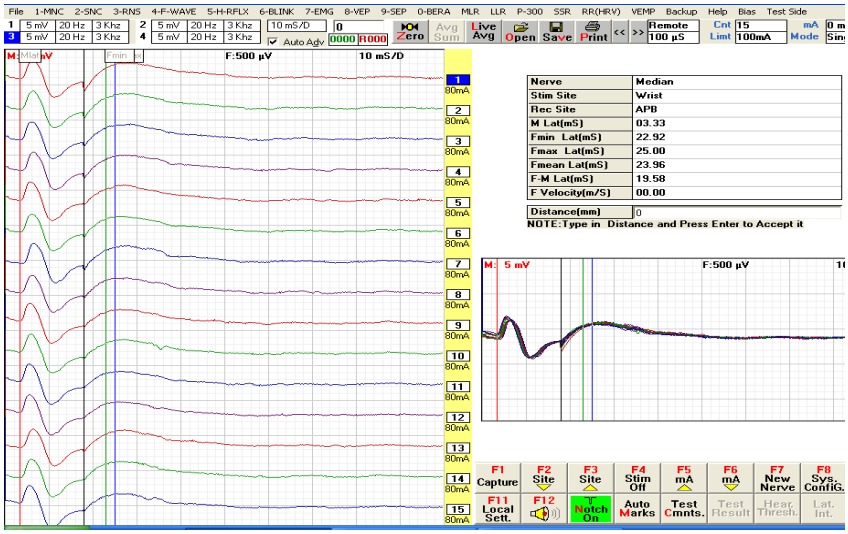
FIG 2.

MEDIAN NERVE F-WAVE STUDY

NORMAL



DIABETIC



DISCUSSION

DN is a common complication of DM and it is encountered in more than one third of diabetic patients(81). Pirar et al(82) had found a five fold increase in the incidence of DN after 25 years of follow up. Although methods of assessing peripheral nerve function are improving, no single test is indicative of nerve disease.(68) The San Antonio conference on diabetic neuropathy(69) recommended obtaining ≥1 measure from each of the following categories to better define and classify diabetic neuropathy: clinical symptoms, clinical examination, electrodiagnostic studies, quantitative sensory testing and autonomic function testing. Likewise we in our study have used NCS as an extension of clinical examination.

Discordance between nerve conduction velocity and symptoms and signs of DN has been reported before.(83,84) We found that 35% of our patients with symptomatic DN had normal NCS, which is higher than that reported by Sangiorgio et al(83) and Fedele et al(84). Also nearly 30% of patients who did not have symptoms related to upper limbs showed some abnormality in NCS. This discordance between symptoms and NCS means that we can not rely on patient's symptoms for the diagnosis of DN and we need NCS for better assessment and diagnosis of DN.

The various clinical types of PN in this study correlate well with most studies all over the world, with sensorimotor polyneuropathy—diagnosed in 48%—being the most common. (71)

Symptoms of PN manifested at a significantly lower age in our study. This is in

agreement with Vondrova and coworkers in Czech, who found that diabetic polyneuropathy manifested at a younger age.(74) The average age of onset was 40 years in males and 42.3 in females.

There were no significant relation between Diabetic neuropathy and sex, BMI, hypertension or hyperlipidemia which is in agreement with the findings of Hillson et al(88) and Maser et al(89)

The relation between smoking and DN is conflicting, some reports showed significant relation(85) while others(16) didn't find any relation. We found no significant relation between Diabetic neuropathy and smoking.

The overall high frequency of diabetic AN in this study (54%) was in keeping with what has been seen by other workers. Fernandez-Castaner and colleagues(76) had reported that 53% of an unselected series of diabetics had symptoms suggestive of autonomic dysfunction, while Thi and coworkers(77) documented that 67.6% of Vietnamese diabetics have cardiac AN. Most studies suggest a fairly close association between AN and sensory neuropathy. This was again true in our case, were all diabetics with AN had an associated somatic neuropathy that precedes abnormalities of autonomic function (78).

While no significant relation has been found between age and abnormal NCS, a strong relation was found with poor glycemic control, this means that even young patients can develop alteration in NCS if they are not well controlled. As the pathogenic mechanisms of Diabetic neuropathy are not fully understood, there is no satisfactory and fundamental therapy for Diabetic neuropathy. Therefore, further researches are needed especially into pathogenic mechanisms in order that satisfactory treatment is achieved. Good glycemic control is essential if the risk of diabetic complications is to be minimized(90).

There was a strong relation between baseline glycated hemoglobin and the loss of tactile sensation and temperature sensation (91). Intensive diabetic control had been shown to reduce the occurrence of clinical neuropathy by 60% (92,93). Several prospective randomized clinical trials have shown the beneficial effect of tight glycemic control on the progression of chronic microvascular complications of DM (94,95). This means that strenuous control of blood glucose is the key in the ultimate prevention of diabetic neuropathy

In our study too prolonged and poorly controlled DM were the most significant factors associated with Diabetic neuropathy as has been reported by others (83,84,85,86). A significant proportion of patients in our study who were on insulin had severe PN. This relationship may have more to do with poor control of diabetes in these patient, rather than insulin usage by itself. Similar to our report Cheng et al(87) had also shown a significant relation between insulin use and Diabetic neuropathy.

Cranial neuropathies are known to occur commonly in diabetics. There are only few studies on the frequency of clinically apparent cranial nerve lesions associated with diabetes mellitus. Large retrospective series revealed 0.97% incidence of oculomotor and facial nerve palsies in diabetic patients over a 25-year period which was 7.5 fold more frequent than in the nondiabetic control group (Urban *et al.*, 1999)(96). Urban *et al.* (l999)(96) reported that 77.5% of their diabetic patients demonstrated a significant prolongation of distal motor latency of VIIth nerve.

Johnson and Waylonis (1964) (97) stressed the fact that, even though the conduction of limb nerves were unaffected, subclinical involvement of the facial nerve was present in a group of known diabetics (Johnson *et al.,* 1964 ; Waylonis *et al.,*\1964) (97). In our study a total of 8(5%) patients had clinical evidence of cranial nerve involvement, among which 6 patients had

facial nerve involvement,2 patients had painful oculomotor palsy. But on nerve conduction studies 14(9%) patients had abnormality in the form of prolonged DML (9patients) and axonal changes(5 patients). Although a few asymptomatic patients in our study did show some NC abnormalities, this was not statistically significant. This may be due to the fact that most of the polyneuropathy in diabetes being length-related, facial nerve conduction may be less impaired than limb nerve conduction.

Several workers have demonstrated subclinical involvement of nerve fibres in patients with diabetes by comparing conduction between patients and normal subjects. These studies concerned patients with or without diabetic neuropathy (Lawrence and Locke, 1961; Mulder et al., 1961; Skillman et al., 1961; Fagerberg et al., 1963; Mayer, 1963; Gamstorp, 1964; Eeg-Olofsson and Petersen, 1966)(101,102,103,104) and mixed groups (Gregersen, 1964, 1967). In the individual patient, slowing in motor conduction was often borderline in the non-affected nerves of patients with isolated peripheral nerve lesions (Gilliatt and Willison, 1962). (105,106,107)

In our study, although we did not include asymptomatic diabetics, we were able to analyze the conduction in clinically unaffected limb (mostly upperlimb). Out of 56 patients who did not have upperlimb symptoms 32 patients showed abnormalities in motor conduction while 15 patients had additional sensory disturbance.

Many patients with sensory motor neuropathy (76 patients) showed a prolongation in distal motor latency in addition to more than 50% reduction in amplitude, this we assume to be due to the loss of myelinated fibres. Also 5 patients with sensory motor neuropathy, in addition to prolongation in latency and reduction in amplitude, showed a significant slowing in conduction velocity pointing to the possibility of additional focal abnormalities.

The slowing in the common peroneal nerve was the electrophysiological parameter most closely related to the severity of the neuropathy (P < 0-001). In previous studies, the average slowing in motor conduction along the median and ulnar nerves has been reported to be as severe as in the common peroneal nerve, both in patients with and without clinical signs of neuropathy (Mulder et al., 1961; Lawrence and Locke, 1962; Mayer, 1963; Gamstorp, 1964;Gregersen, 1967).(116,117,118,101)

In our patients, distal slowing as measured by DML was as pronounced in the upper as in the lower extremities, but in the more proximal segments of the nerves (as measured by F wave latency) slowing was 1.5 times greater in the lower limb nerves than in the upper. This is consistent with the findings of Skillman et al. (1961) (119) and of Johnson (1962) (124) and with the more pronounced clinical involvement of the legs than of the arms.

The 2 main pathophysiologic mechanisms proposed for diabetic neuropathy are nerve ischemia (microangiopathy) and metabolic derangement of nerves. However, DM is one of the group of autoimmune disorders, [126,127] and there is growing evidence that immune and inflammatory processes play a role in some of the neuropathies occurring in DM, including demyelinating polyneuropathy.[128,129] Mitchell et al 7 reported finding major histocompatibility class II antigen expression on Schwann cells, similar to that found in I-CIDP, in the nerves of patients with diabetic amyotrophy. Younger et al 8 found that upto 60% of sural nerve biopsy specimens from 20 diabetic patients with various types of neuropathy had lymphocyticmicrovasculitis or perivasculitis, and endoneurial T-cell infiltrates, with increased expression of tumor necrosis factor α cytokines, and components of the membrane attack complex. Several studies have suggested that autoantibodies directed against phospholipid, 130,131 gangliosides, sulphatide, nerve growth factor, and advanced glycation end products

may play a role in the pathogenesis of diabetic neuropathy. This probably explains the large number of patients in our study showing focal changes in NCS.

Limitation of our study:

1. Potential bias of patient referral. Most of the patients referred to our OPD had a severe neuropathy
2. Lack of biopsy correlation.

CONCLUSIONS

1) Among the different types of Diabetic neuropathy, chronic sensorimotor neuropathy was the commonest, with a prevalence of 48%. Autonomic neuropathy had a prevalence of 31.4%. AN was almost always associated with sensory neuropathy. Among the focal neuropathies CIDP was the commonest

2) 65% of patients with clinical neuropathy showed abnormalities on nerve conduction studies and the remaining had normal NCS but they had features of small fiber neuropathy with autonomic signs. Nearly 30% of patients with no upper limb symptoms showed abnormalities in NCS. showing a discordance between symptoms and nerve conduction studies

3) Longer duration of DM strongly correlated with abnormalities in NCS, the mean duration of 7.4 years in patients with NCS abnormalities compared to 3.1 years in those with only lower limb NCS changes.

4) Prolonged poorly controlled diabetes was an important risk factor associated with diabetic neuropathy. Aggressive/strict control of blood glucose is the key in the ultimate prevention of diabetic neuropathy

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PROFORMA

INSTITUTE OF NEUROLOGY
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Name: **Age/Sex:**

MIN No: **I.P.No**

HISTORY: **Duration of Diabetes**

DURATION:

	Lower Limbs		Upper Limbs	
	RT	**LT**	**RT**	**LT**
Sensory symptoms				
Numbness :				
Paresthesias :				
Sensory loss :				
Touch, Pain, Temperature Loss :				
Autonomic symptoms				
Postural Giddiness :				
sweating disturbances :				
Bladder and bowel symptoms :				
Erectile dysfunction :				
Weakness Distal :				
Proximal :				
Atrophy :				
Other system involvement :				

PAST HISTORY:
HT /HYPOTHYROIDISM / RA / TRAUMA/ TB / RENAL FAILURE

FAMILY HISTORY:

OCCUPATION:

PERSONAL HISTORY: smoker/alcoholic/substance abuse

SIGNS: Cranial Nerves

	Lower Limbs		Upper Limbs	
	RT	**LT**	**RT**	**LT**

Spinomotor

Atrophy :

Weakness Distal :

Proximal :

Reflexes :

Sensory loss

Touch, Pain, Temperature :

Vibration and JPS :

Romberg's test :

Autonomic Functions

Sweating and Trophic changes:

Bp HR Response to posture :

HR response to Deep breathing :

Valsalva maneuver :

INVESTIGATIONS:

TC DC ESR	Blood sugar					
	F	PP	GTT	HbA1C	ECG	OTHERS

INSTITUTE OF NEUROLOGY

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NERVE CONDUCTION STUDY

Name: **Age/Sex:** **Date:** **MIN No:** **Unit:**

MOTOR NERVE CONDUCTION STUDY

Nerve	Distal Latency (ms)	Amplitude (mv)	CV (m/s)	F-Wave Latency (ms)
Median				
Ulnar				
Tibial				
Peroneal				
Facial				

Sensory Nerve Conduction Study

Nerve	Latency	Amplitude (uV)	CV (m/s)
Median			
Ulnar			
Sural			

CONCLUSION:

Master Chart

MASTER CHART

ge ars)	Sex M/F	Duration of DM (Years)	Duration of Symptoms	Distal Motor Latency				Distal Motor Amplitude				Nerve conduction		
				Median	Ulnar	Tibial	Peroneal	Median	Ulnar	Tibial	Peroneal	Median	Ulnar	Tib
2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(1
8	M	6	2 y	N	N	N	N	D	N	N	N	N	N	N
1	M	9	2 y	N	N	N	I	N	D	N	D	N	N	N
3	F	9	4 m	N	N	N	N	N	N	N	N	N	N	N
1	M	4	2 y	I	N	I	N	D	N	D	D	D	N	D
3	M	11	2 y	I	N	N	N	N	D	D	D	D	N	N
2	F	7	2 y	NR	I	NR	I	NR	D	NR	N	NR	D	N
5	F	3	4 m	N	N	N	N	N	N	N	N	N	N	N
2	M	5	7 m	I	N	N	N	N	N	D	D	D	N	N
3	M	8	6 m	I	N	N	N	D	N	D	D	D	N	N
4	F	4	4 m	I	N	NR	I	N	N	NR	N	D	N	N
4	M	10	3 y	NR	I	NR	NR	NR	D	NR	NR	NR	D	N
7	F	6	1y	N	N	I	N	D	D	D	D	N	N	D
2	F	8	7 m	I	N	N	N	D	D	D	N	D	N	N
5	M	4	7 m	N	N	N	N	N	N	N	N	N	N	N
1	F	11	8 m	N	N	N	N	D	N	D	D	N	N	N
8	F	7	9 m	N	N	N	N	N	D	N	N	N	N	N

5	M	4	4 m	N	N	I	N	D	N	N	D	N	N	N
7	M	7	2 y	N	I	N	NR	D	N	D	NR	N	D	N
0	F	9	2y	N	N	N	N	N	N	N	N	N	N	N
9	F	5	1 y	N	N	I	N	D	N	N	N	N	N	D
1	M	2	4 m	N	N	N	N	D	D	N	D	N	N	N
3	M	8	8 m	N	N	NR	I	D	D	D	N	N	N	N
9	M	6	5 m	N	N	N	N	N	N	N	N	N	N	N
2	M	10	3 m	N	N	I	N	D	D	N	N	N	N	D
1	F	2	5 m	N	N	N	NR	D	N	N	NR	N	N	N

N – Normal I – Increased D – Decreased NR – No Response y - years

m – months

No	F-Wave Latency				Sensory Amplitude			Sensory Conduction Velocity Sural	Conduction Block	Temporal Dispertion	Clincal Type of Neuropat
	Median	Ulnar	Tibial	Peroneal	Median	Ulnar	Sural				
	(18)	(19)	(20)	(21)	(22)	(23)	(24)	(25)	(26)	(27)	(28)
1. 1	N	N	N	N	N	N	N	D			Painful Distal Senso
2.	I	N	I	N	N	N	D	N			Symmetric Sensorimo
3.	N	N	N	N	N	N	N	N	-	-	Painful Distal Senso
4.	I	N	I	N	D	N	D	N			Symmetric Sensorimo
5.	N	N	I	NR	N	N	NR	NR		+	Symmetric Sensorimo
6.	NR	N	NR	I	D	N	D	N			Symmetric Sensorimo
7.	N	N	N	N	N	N	N	N	-	-	Painful Distal Senso
8.	N	N	I	I	N	D	D	N			Symmetric Sensorimo
9.	N	N	I	N	D	N	D	N			Symmetric Sensorimo
10	N	N	NR	N	N	D	D	D			Symmetric Sensorimo
11	NR	I	NR	NR	NR	NR	NR	NR	+	+	CIDP
12	N	N	N	N	D	N	D	N			Symmetric Sensorimo
13	N	N	I	N	N	D	D	N			Symmetric Sensorimo
14	N	N	N	N	N	N	N	N	-	-	Painful Distal Senso
15	N	N	I	I	D	N	NR	NR			Symmetric Sensorimo
16	I	N	N	NR	N	D	D	D		+	Symmetric Sensorimo
17	N	N	I	N	D	N	D	N			Symmetric Sensorimo
18	I	N	N	NR	D	D	D	N		+	Symmetric Sensorimo
19	N	N	N	N	N	N	N	N	-	-	Painful Distal Senso
20	N	N	N	-	N	D	D	N			Symmetric Sensorimo
21	N	N	I	NR	N	N	D	N		+	Symmetric Sensorimo
22	I	N	NR	N	D	D	D	D			Symmetric Sensorimo
23	N	N	N	N	N	N	N	N	-	-	Painful Distal Senso
24	I	N	I	I	D	N	D	N		+	Symmetric Sensorimo
25	N	I	N	NR	D	N	N	N			Symmetric Sensorimo

N – Normal I – Increased D – Decreased NR – No Response y - years
m – months

Age	Sex	Duration of DM	Duration of Symptoms	Distal Motor Latency				Distal Motor Amplitude				Nerve conduction velocit			
				Median	Ulnar	Tibial	Peroneal	Median	Ulnar	Tibial	Peroneal	Median	Ulnar	Tibial	F
(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	
53	M	4	2 y	N	N	N	N	D	N	D	N	N	N	N	
62	F	6	1 y	N	N	N	N	D	D	N	D	N	N	N	
65	F	7	2 y	N	N	N	N	N	N	N	N	N	N	N	
43	M	3	4 m	N	N	N	N	N	N	N	N	N	N	N	
51	F	6	4 m	I	N	N	N	N	D	D	D	D	N	N	
37	M	6	5 m	N	N	I	N	D	N	D	N	N	N	N	
61	M	9	2 y	I	N	NR	N	D	N	NR	D	D	N	NR	
47	M	5	1 y	I	I	N	N	D	D	N	N	D	D	N	
59	F	4	4 m	I	N	N	NR	N	N	N	NR	D	N	N	
57	M	7	7 m	I	N	I	N	D	N	D	D	D	N	D	
62	M	6	1 y	N	N	N	I	N	N	D	D	N	N	N	
38	F	3	5 m	I	N	N	N	N	N	N	D	D	N	N	
64	M	7	1 y	N	N	N	N	N	N	N	N	N	N	N	
58	M	8	5 m	NR	N	N	N	NR	D	D	N	NR	N	N	
45	F	5	1 y	I	N	I	N	D	N	N	N	N	N	D	
61	M	11	2 y	N	N	NR	N	N	N	N	N	N	N	NR	
39	M	4	11 m	N	N	N	N	N	N	N	N	N	N	N	
50	M	6	1 y	N	I	N	N	D	N	D	D	N	N	N	
58	M	9	2 y	N	N	N	N	N	N	N	N	N	N	N	
52	F	7	5 m	N	N	N	N	N	N	N	N	N	N	N	
45	M	4	4 m	N	N	N	I	I	D	N	N	N	N	N	
62	F	7	4 m	N	N	NR	N	I	D	D	D	N	N	N	
57	F	5	1 y	N	N	N	N	N	N	N	N	N	N	N	
49	M	2	1 m	NR	I	I	I	NR	N	D	D	NR	D	D	
45	F	7	1 y	N	N	N	N	I	D	D	N	N	N	N	

N – Normal I – Increased D – Decreased NR – No Response y - years
m – months

F-Wave Latency				Sensory Amplitude			Sensory Conduction Velocity Sural	Conduction Block	Temporal Dispertion	Clincal Type of Neu
Median	Ulnar	Tibial	Peroneal	Median	Ulnar	Sural				
(18)	(19)	(20)	(21)	(22)	(23)	(24)	(25)	(26)	(27)	(28)
N	N	I	NR	D	N	D	D			Symmetric Sensori
I	I	I	N	N	D	D	N			Symmetric Sensori
N	N	N	N	N	N	N	N	-	-	Painful Distal Sen
N	N	N	N	N	N	N	N	-	-	Painful Distal Sen
N	I	N	I	D	D	D	N		+	Symmetric Sensori
I	N	I	N	N	N	NR	NR			Symmetric Sensori
N	I	NR	NR	D	D	D	N		+	Painful Distal Sen
I	N	I	N	N	N	D	N			Symmetric Sensori
N	I	N	NR	N	D	-	D			Painful Distal Sen
I	N	N	I	D	N	D	N			Symmetric Sensori
N	N	I	I	N	N	NR	NR		+	Lumbosacral radiculoneuropa
N	I	I	N	N	D	D	D			Symmetric Sensori
I	N	N	NR		N	-	D			Painful Distal Sen

NR	N	I		N	D	D	N			Symmetric Sensori
N	N	N	NR	D	N	NR	D		+	Painful Distal Sen
I	NR	NR	N	D	D	D	D			Symmetric Sensori
N	N	N	NR	D	N	NR	NR			Symmetric Sensori
I	I	I	I	N	D	D	N		+	Symmetric Sensori
N	N	N	N	N	N	N	N	-	-	Painful Distal Sen
N	N	N	N	N	N	N	N	-	-	Painful Distal Sen
I	I	I	N		N	D	D			Symmetric Sensori
N	N	NR	I	D	D	D	N			Symmetric Sensori
N	N	N	N	N	N	N	N	-	-	Painful Distal Sen
NR	I	I	I	NR	N	N	N	-	+	AIDP
I	I	I	NR	D	N	D	N			Symmetric Sensori

N – Normal I – Increased D – Decreased NR – No Response y - years

m – months

ge	Sex	Duration of DM	Duration of Symptoms	Distal Motor Latency					Distal Motor Amplitude				Nerve conduction velo		
				Median	Ulnar	Tibial	Peroneal	Facial	Median	Ulnar	Tibial	Peroneal	Median	Ulnar	Tibial
2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)
3	M	6	9 m	N	N	N	N	N	N	N	N	N	N	N	N
6	F	7	2 y	NR	N	I	N	N	NR	D	D	D	NR	N	D
7	M	7	1 y	N	N	N	N	N	D	N	N	D	N	N	N
3	F	6	1 y	N	N	N	I	N	D	N	N	D	N	N	N
6	M	3	8 m	N	N	N	N	I	D	N	D	D	N	N	D
7	F	6	1 y	I	N	N	I	N	D	D	N	N	D	N	N
5	M	7	2 y	I	N	N	NR	N	N	N	N	NR	D	N	N
4	F	2	4 m	I	I	N	I	N	D	N	N	N	N	D	N
1	M	8	1 m	I	I	I	I	N	N	N	D	D	D	D	D
7	F	6	1 y	N	N	N	N	N	N	N	N	N	N	N	N
3	M	5	1 y	N	I	N	I	N	D	D	N	N	N	D	N
1	M	12	3 y	N	N	N	N	N	N	N	N	N	N	N	N
7	M	6	6 m	NR	I	N	N	N	NR	N	D	D	NR	D	N
2	F	7	2 y	N	N	N	N	N	N	N	N	N	N	N	N
7	M	4	1 y	I	I	NR	NR	N	N	D	NR	NR	D	D	NR
2	F	3	11 m	I	N	N	N	N	D	N	D	N	D	N	N
7	F	5	6 m	I	N	N	I	N	N	D	D	D	D	N	N
6	M	8	1 y	I	N	I	NR	N	D	D	N	NR	N	N	D
3	F	5	4 m	N	N	N	N	N	N	N	N	N	N	N	N
3	M	4	7 m	I	I	N	N	N	D	D	D	N	N	D	N
5	M	6	5 m	N	N	N	N	N	N	N	N	N	N	N	N
2	M	4	7 m	I	N	I	I	N	D	N	N	D	N	N	D
6	F	7	1 y	N	N	I	N	N	N	N	N	N	N	N	D
9	M	2	4 m	N	N	N	N	N	N	N	NR	D	N	N	N
6	F	4	9 m	N	N	N	N	N	D	N	N	N	N	N	N

N – Normal I – Increased D – Decreased NR – No Response y - years

m – months

	F-Wave Latency				Sensory Amplitude			Sensory Conduction Velocity Sural	Conduction Block	Temporal Dispertion	Clincal Type of Neuropa
	Median	Ulnar	Tibial	Peroneal	Median	Ulnar	Sural				
	(18)	(19)	(20)	(21)	(22)	(23)	(24)	(25)	(26)	(27)	(28)
	N	N	N	N	N	N	N	N	-	-	Painful Distal Senso
	NR	I	I	I	D	D	D	N		+	Symmetric Sensorimo
	N	N	N	NR	N	N	D	N			Symmetric Sensorimo
	I	N	I	N	D	D	NR	NR			Symmetric Sensorimo
	N	N	N	N	N	N	D	D			Cranial neuropathy
	I	I	I	N	N	D	D	D			Symmetric Sensorimo
	N	N	N	NR	D	N	-	N		+	Symmetric Sensorimo
	I	I	I	-	N	D	D	N			Symmetric Sensorimo
	I	I	NR	I	N	N	N	N	-	+	AIDP
	N	N	N	N	N	N	N	N	-	-	Painful Distal Senso
	I	N	I	I	N	D	NR	NR		+	Symmetric Sensorimo
	N	N	N	N	N	N	N	N	-	-	Painful Distal Senso
	NR	N	N	N	D	D	D	N			Symmetric Sensorimo
	N	I	I	I	N	D	-	-			Painful Distal Senso
	I	I	NR	NR	NR	NR	NR	NR	+	+	CIDP
	I	N	I	I	N	N	D	N			Symmetric Sensorimo
	N	NR	N	N	D	D	D	N			Symmetric Sensorimo
	I	I	I	NR	N	N	D	N			Symmetric Sensorimo
	N	N	N	N	N	N	N	N	-	-	Painful Distal Senso
	I	N	I	I	D	D	D	D			Symmetric Sensorimo
	N	N	N	N	N	N	N	N	-	-	Painful Distal Senso
	N	I	I	N	N	D	D	D			Symmetric Sensorimo
	I	N	I	N	D	N	-	-			Symmetric Sensorimo
	N	N	N	N	N	D	D	N			Cranial neuropathy
	N	N	I	I		D	NR	NR		+	Symmetric Sensorimo

N – Normal I – Increased D – Decreased NR – No Response y - years

m – months

Age	Sex	Duration of DM	Duration of Symptoms	Distal Motor Latency				Distal Motor Amplitude				Nerve conduction velo		
				Median	Ulnar	Tibial	Peroneal	Median	Ulnar	Tibial	Peroneal	Median	Ulnar	Tibial
(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)
51	M	3	4 m	N	N	N	N	N	N	N	N	N	N	N
46	M	9	2 y	N	N	N	I	D	N	D	D	N	N	N
52	F	6	1 y	N	N	I	N	D	D	N	N	N	N	D
33	M	3	4 m	I	N	I	NR	N	N	N	NR	D	D	D
59	F	4	11 m	N	N	N	N	N	N	N	N	N	N	N
41	F	5	9 m	N	N	N	N	N	N	N	N	N	N	N
58	M	4	9 m	N	N	I	N	D	D	N	D	N	N	N
61	M	8	2 y	N	N	NR	N	D	N	NR	N	N	N	NR
53	M	7	1 y	I	N	N	N	N	N	N	N	D	N	N
42	M	10	1 m	I	I		NR	D	N	D	NR	D	D	D
51	F	3	3 m	I	I	N	N	D	D	D	D	D	D	D
60	M	3	4 m	I	N	I	NR	N	D	D	NR	N	N	D
61	M	4	5 m	N	N	NR	N	D	D	N	D	N	N	NR
34	F	5	1 y	N	N	N	N	N	N	N	N	N	N	N
45	M	7	2 y	I	N	I	I	N	N	D	D	D	D	D
66	M	10	3 y	I	I	N	N	N	D	N	N	N	D	D
36	M	4	5 m	I	N	N	N	D	D	D	N	D	N	N
59	F	2	4 m	N	NR	N	I	N	NR	N	D	N	NR	N
56	M	9	2 y	N	N	N	N	D	N	D	D	N	N	D
58	F	6	1 y	I	N	N	I	N	D	N	N	N	N	N
62	M	4	6 m	N	N	N	N	N	N	N	N	N	N	N
33	F	5	1 y	N	N	N	N	N	N	N	N	N	N	N
58	M	6	1 y	I	I	I	N	N	N	D	D	D	D	D
50	M	7	2 y	N	N	I	I	D	N	D	D	N	N	D
56	F	7	1 y	N	N	N	NR	D	D	N	NR	N	N	N

N – Normal I – Increased D – Decreased NR – No Response y - years
m – months

F-Wave Latency				Sensory Amplitude			Sensory Conduction Velocity Sural	Conduction Block	Temporal Dispertion	Clincal Type of Neuropathy
Median	Ulnar	Tibial	Peroneal	Median	Ulnar	Sural				
(18)	(19)	(20)	(21)	(22)	(23)	(24)	(25)	(26)	(27)	(28)
N	N	N	N	N	N	N	N	-	-	Painful Distal Sensory
I	I	N	I	D	D	D	D		+	Symmetric Sensorimoto
N	N	I	N	N	N	D	N			Symmetric Sensorimoto
I	I	N	NR	D	D	D	N			Symmetric Sensorimoto
N	N	N	N	N	N	N	N	-	-	Painful Distal Sensory
I	I	I	N	N	D	D	N	+		Cranial Neuropathy(Facial-Re amp)
N	N	I	NR	D	N	NR	NR			Symmetric Sensorimoto
I	N	NR	N	N	D	D	N			Symmetric Sensorimoto
NR	N	I	NR	N	N	D	D		+	Symmetric Sensorimoto
I	I	I	NR	N	N	N	N	-	-	AIDD
N	NR	N	N	D	D	D	N			Symmetric Sensorimoto
N	I	I	NR	N	N	-	-			Painful Distal Sensory
I	N	NR	I	D	D	D	D			Symmetric Sensorimoto
N	N	N	N	N	N	N	N	-	-	Painful Distal Sensory
I	I	I	I	D	N	NR	NR	+	+	CIDP
I	I	-	NR	N	D	D	D			Symmetric Sensorimoto
N	N	N	I	D	N	D	N			Symmetric Sensorimoto
I	NR		N	N	D	D	D			Symmetric Sensorimoto
I	N	NR	NR	D	D	NR	NR			Mononeuritis Multiplex
N	I	I	I	N	N	D	N			Symmetric Sensorimoto
N	N	N	N	N	N	N	N	-	-	Painful Distal Sensory
I	N	N	N	N	N	N	N	-	-	Painful Distal Sensory
N	I	N	I	D	D	-	-			Mononeuritis Multiplex
I	N	I	N	D	N	D	N			Symmetric Sensorimoto
I	I	N	NR	N	D	D	N			Symmetric Sensorimoto

N – Normal I – Increased D – Decreased NR – No Response y - years

m – months

Age	Sex	Duration of DM	Duration of Symptoms	Distal Motor Latency				Distal Motor Amplitude				Nerve conduction velo			
				Median	Ulnar	Tibial	Peroneal	Median	Ulnar	Tibial	Peroneal	Median	Ulnar	Tibial	Pe
(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	
52	M	2	4m	N	N	I	N	D	D	N	N	N	N	D	
60	F	7	1y	N	I	N	I	N	N	N	D	N	D	N	
36	F	6	1y	N	N	I	I	D	D	N	D	N	N	D	
61	M	4	5m	N	N	N	N	N	N	N	N	N	N	N	
41	M	5	1y	I	I	I	NR	N	D	D	NR	D	D	D	
43	F	4	6m	N	N	-	N	D	NR	D	D	N	N	N	
42	F	2	11m	N	N	N	N	N	N	N	N	N	N	N	
62	M	6	1y	NR	N	I	N	NR	N	D	N	NR	N	D	
55	M	5	4m	N	N	N	N	D	D	D	D	N	N	N	
51	F	7	2y	I	I	-	N	N	N	N	N	D	D	N	
59	M	6	1y	I	N	I	NR	D	D	N	N	N	N	D	
42	M	2	9m	N	N	N	N	N	N	N	N	N	N	N	
64	M	7	1y	I	N	I	I	D	D	D	D	D		D	
36	M	4	1y	I	I	NR	NR	N	D	NR	NR	D	D	NR	

52	M	9	1y	I	I	I	N	D	N	D	N	D	D	D	
55	F	4	9m	I	I	NR	N	D	N	NR	N	N	N	NR	
54	M	11	3y	N	N	NR	NR	N	N	NR	NR	N	N	NR	
53	F	3	7m	I	N	N	N	D	N	N	D	N	N	N	
60	M	6	6m	N	N	N	N	N	N	N	N	N	N	N	
48	M	4	2y	I	N	N	N	D	D	D	D	N	N	N	
62	M	7	9m	NR	I	NR	N	NR	N	NR	D	NR	NR	N	
51	M	3	1y	N	NR	N	I	D	NR	N	N	N	NR	N	
32	F	4	2y	N	N	N	N	D	N	N	N	N	N	N	
63	M	6	5m	N	I	NR	NR	D	D	NR	D	N	D	NR	
58	F	6	1y	N	I	N	N	D	N	N	N	N	D	N	

N – Normal I – Increased D – Decreased NR – No Response y - years

m – months

F-Wave Latency				Sensory Amplitude			Sensory Conduction Velocity Sural	Conducti on Block	Temporal Dispertion	Clincal Type of Neuropathy
Me ian	Ulnar	Tibial	Perone al	Median	Ulnar	Sural				
18)	(19)	(20)	(21)	(22)	(23)	(24)	(25)	(26)	(27)	(28)
I	N	N	NR	D	D	NR	NR			Symmetric Sensorimotor
N	NR	N	N	N	N	D	D			Symmetric Sensorimotor
I	I	-	I	D	D	D	D	+		Symmetric Sensorimotor
N	N	N	N	N	N	N	N	--	--	Painful Distal Symmetric
I	N	I	NR	N	N	N	D			CIDP
N	I	I	-	D	D	D	N			Symmetric Sensorimotor
N	N	N	N	N	N	N	N	--	--	Painful Distal Symmetric
NR	I	N	I	N	N	D	N		+	Symmetric Sensorimotor
N	N	I	NR	NR	NR	NR	NR	--	--	Mononeuritis Multiplex
I	N	N	N	D	D	D	N			Symmetric Sensorimotor
I	I	-	NR	N	N	D	N			Symmetric Sensorimotor
N	N	N	N	N	N	N	N	--	--	Painful Distal Symmetric
N	I	-	I	D	D	D	N			Symmetric Sensorimotor
I	I	NR	NR	N	N	NR	NR	--	--	AIDP
N		I	N	D	N	D	N			Symmetric Sensorimotor
I	NN	NR	I	D	D	N	N			Symmetric Sensorimotor
N	N	NR	NR	N	NR	NR	NR	--	--	Lumbosacral radiculoneuropa
I	NR	N	I	N	N	N	N			Symmetric Sensorimotor
N	N	-	N	N	N	N	N			Cranial Neuropathy(Facial-Reduc
I	N	N	NR	N	N	D	N	+		Symmetric Sensorimotor
NR	I	NR	I	D	N	N	D			Symmetric Sensorimotor
I	N	I	I	N	D	N	N			Symmetric Sensorimotor
N	I	N	NR	D	N	D	N			Symmetric Sensorimotor
I	N	NR	N	N	D	N	D			Symmetric Sensorimotor
N	I	I	N	D	N	D	N			Symmetric Sensorimotor

N – Normal I – Increased D – Decreased NR – No Response y - years
m – months

Age	Sex	Duration of DM	Duration of Symptoms	Distal Motor Latency				Distal Motor Amplitude				Nerve conduction velo			
				Median	Ulnar	Tibial	Peroneal	Median	Ulnar	Tibial	Peroneal	Median	Ulnar	Tibial	F
(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	
59	M	4	4m	N	N	-	N	D	N	D	D	N	N	-	
31	M	2	4m	NR	N	-	I	NR	D	N	N	NR	N	-	
65	F	7	1y	N	N	N	N	N	N	N	N	N	N	N	
49	M	7	7m	I	I	I	NR	D	N	D	NR	D	D	D	
50	F	6	6m	N	NR	N	N	D	NR	D	N	N	NR	N	
56	M	6	1y	N	N	N	N	N	N	N	N	N	N	N	
48	F	7	1y	NR	N	N	N	N	N	N	N	NR	N	N	
46	M	11	1m	I	N	I	I	N	N	N	N	D	D	D	
62	F	3	6m	I	N	N	N	D	N	N	N	N	N	N	
63	F	5	2y	N	N	N	N	N	N	N	N	N	N	N	
38	M	6	1y	I	N	I	I	N	D	D	D	N	N	N	
53	M	12	3y	I	N	N	N	N	N	N	N	N	N	N	
57	F	5	9m	I	N	I	N	D	D	N	N	D	N	D	
62	M	10	2y	N	N	N	N	N	N	N	N	N	N	N	
63	F	6	1y	N	N	N	N	N	N	N	N	N	N	N	
43	M	3	6m	NR	N	I	NR	N	N	N	NR	NR	N	D	
55	F	7	4m	N	N	N	N	N	N	N	N	N	N	N	
38	M	4	1y	I	I	I	NR	N	N	D	NR	D	D	D	
61	F	2	6m	N	N	I	N	D	D	N	N	N	N	D	
63	M	6	4m	NR	I	I	N	D	NR	D	N	NR	NR	N	
53	F	7	1y	N	N	N	I	D	D	N	N	N	N	N	
40	F	6	4m	N	N	N	N	N	N	N	N	N	N	N	
51	F	4	7m	NR	N	I	I	NR	N	D	D	NR	N	D	
64	M	3	6m	N	N	N	N	D	N	N	D	N	N	N	
33	M	2	4m	N	N	I	NR	D	D	NR	N	N	N	D	

N – Normal I – Increased D – Decreased NR – No Response y - years
m – months

F-Wave Latency				7mSensory Amplitude			Sensory Conduction Velocity Sural	Conduction Block	Temporal Dispertion	Clincal Type of Neuropa
Median	Ulnar	Tibial	Peroneal	Medi4man	Ulnar	Sural				
(18)	(19)	(20)	(21)	(22)	(23)	(24)	(25)	(26)	(27)	(28)
I	N	N	N	D	D	D	D			Symmetric Sensorimot
NR	I	-	I	N	N	D	D			Symmetric Sensorimot
N	N	N	N	N	N	N	N	--	--	Painful Distal Symmetr
I	I	I	NR	NR	D	NR	NR	+	+	CIDP
I	NR	I	I	D	N	D	-			Symmetric Sensorimot
N	N	N	N	N	N	N	N	--	--	
NR	N	-	N	D	D	-	D			Symmetric Sensorimot
I	I	I	I	N	N	D	NR	--	--	AIDP
I	N	I	N	D	D	D	D			Symmetric Sensorimot
N	N	N	N	N	N	N	N	--	--	Painful Distal Symmetr
I	I	I	N	D	N	NR	NR			Symmetric Sensorimot
N	N	N	N	N	N	N	N			Cranial Neuropathy(Facial↓
I	I	I	NN	D	N	N	N			Symmetric Sensorimot
N	N	N	N	N	N	N	N	--	--	Painful Distal Symmetr
N	N	N	N	N	N	N	N	--	--	Painful Distal Symmetr
NR	I	I	NR	N	D	D	N			Symmetric Sensorimot
N	N	N	N	N	N	N	N	--	--	Painful Distal Symmetr
I	I	I	NR	D	D	D	NR	+	+	CIDP
I	NR	II	I	N	N	N	N			Symmetric Sensorimot
N	N	N	NR	D	D	D	N			Symmetric Sensorimot
I	I	I	I	N	N	-	-			Symmetric Sensorimot
N	N	N	N	N	N	N	N	--	--	Painful Distal Symmetr
N	N	I	I	N	N	D	NR	--	--	Lumbosacral radiculoneuro
N	I	-	N	D	D	D	N			Symmetric Sensorimot
I		N	NR	D	NR	N	N			Symmetric Sensorimot
N	N	I	NR	N	D	D	N			Symmetric Sensorimot

N – Normal I – Increased D – Decreased NR – No Response y - years
m – months

Pt.No.	Age	Sex	Duration of DM	Duration of Symptoms	Distal Motor Latency				Distal Motor Amplitude				Ne
					Median	Ulnar	Tibial	Peroneal	Median	Ulnar	Tibial	Peroneal	Median
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)
151	61	M	3	7m	N	NR	N	I	D	NR	N	N	N
152	39	F	5	4m	N	N	N	N	N	N	N	N	N
153	62	M	5	1y	N	N	N	N	D	D	D	N	N
154	34	M	7	9m	N	NR	N	N	D	NR	N	D	N
155	64	M	2	4m	N	N	N	N	N	N	N	N	N
156	49	F	6	1y	I	N	N	N	D	N	N	D	D

Pt.No	F-Wave Latency				Sensory Amplitude			Sensory Conduction Velocity Sural	Conducti on Block	Temporal Dispertion	Clinca
	Me dian	Ulnar	Tibial	Perone al	Median	Ulnar	Sural				
	(18)	(19)	(20)	(21)	(22)	(23)	(24)	(25)	(26)	(27)	
151	N	NR	I	N	D	NR	D	D			Sym
152	N	N	N	N	N	N	N	N	--	--	Pain
153	I	N	N	I	D	N	D	D			Symm
154	N	NR	I	NR	N	D	D	D			Symm
155	I	N	N	N	N	N	N	N			Crani
156	N	N	N	NR	D	N	D	D			Sym

N – Normal I – Increased D – Decreased NR – No Response y - years
m – months